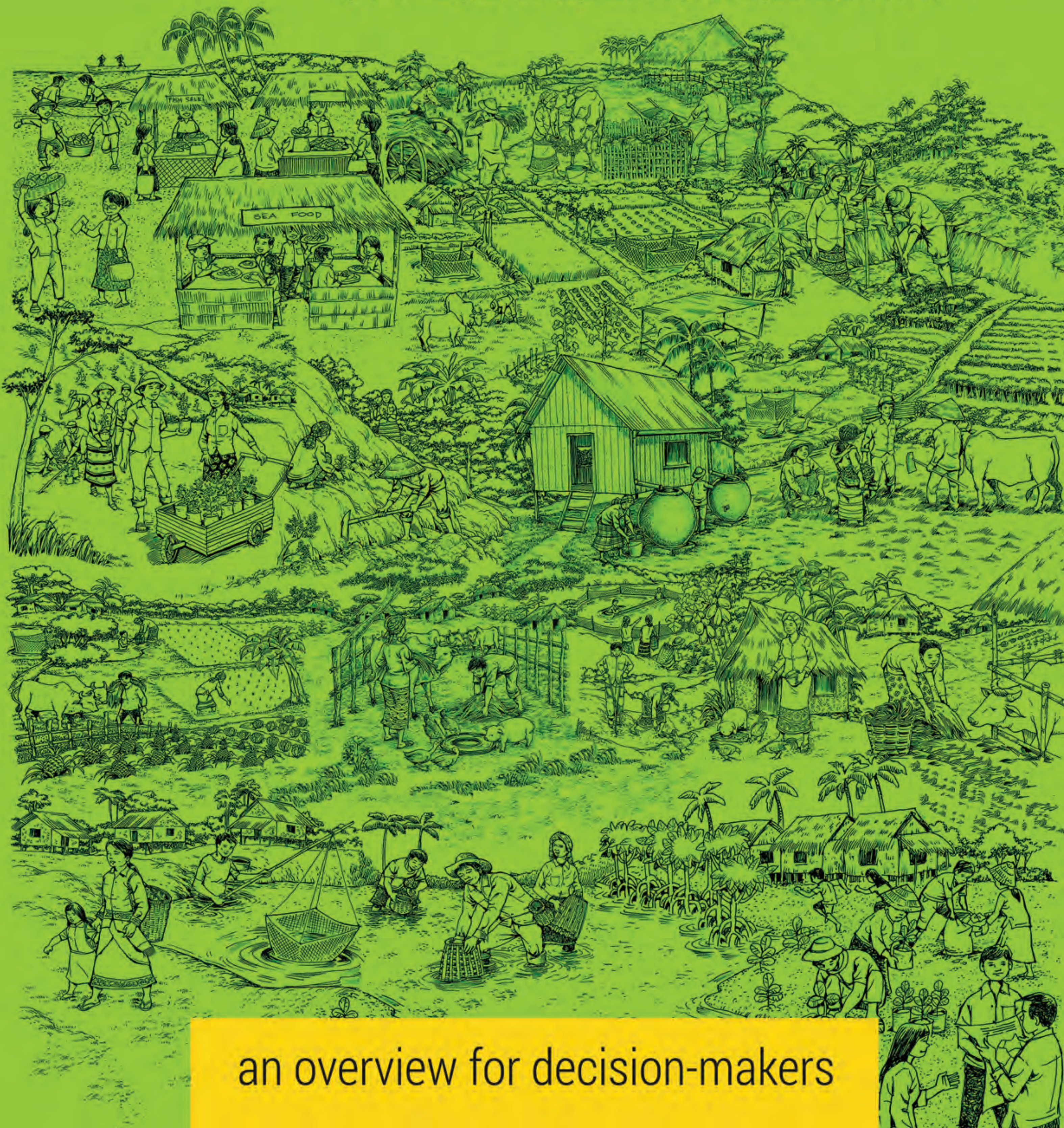
Towards CLIMATE RESILIENCE in AGRICULTURE for Southeast Asia



an overview for decision-makers

The International Center for Tropical Agriculture (CIAT) – a member of the CGIAR Consortium – develops technologies, innovative methods, and new knowledge that better enable farmers, especially smallholders, to make agriculture eco-efficient – that is, competitive and profitable as well as sustainable and resilient. Headquartered near Cali, Colombia, CIAT conducts research for development in tropical regions of Latin America, Africa, and Asia.

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CIAT leads the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which brings together the world's best researchers in agricultural science, development research, climate science, and Earth System science, to identify and address the most important interactions, synergies, and tradeoffs between climate change, agriculture, and food security.

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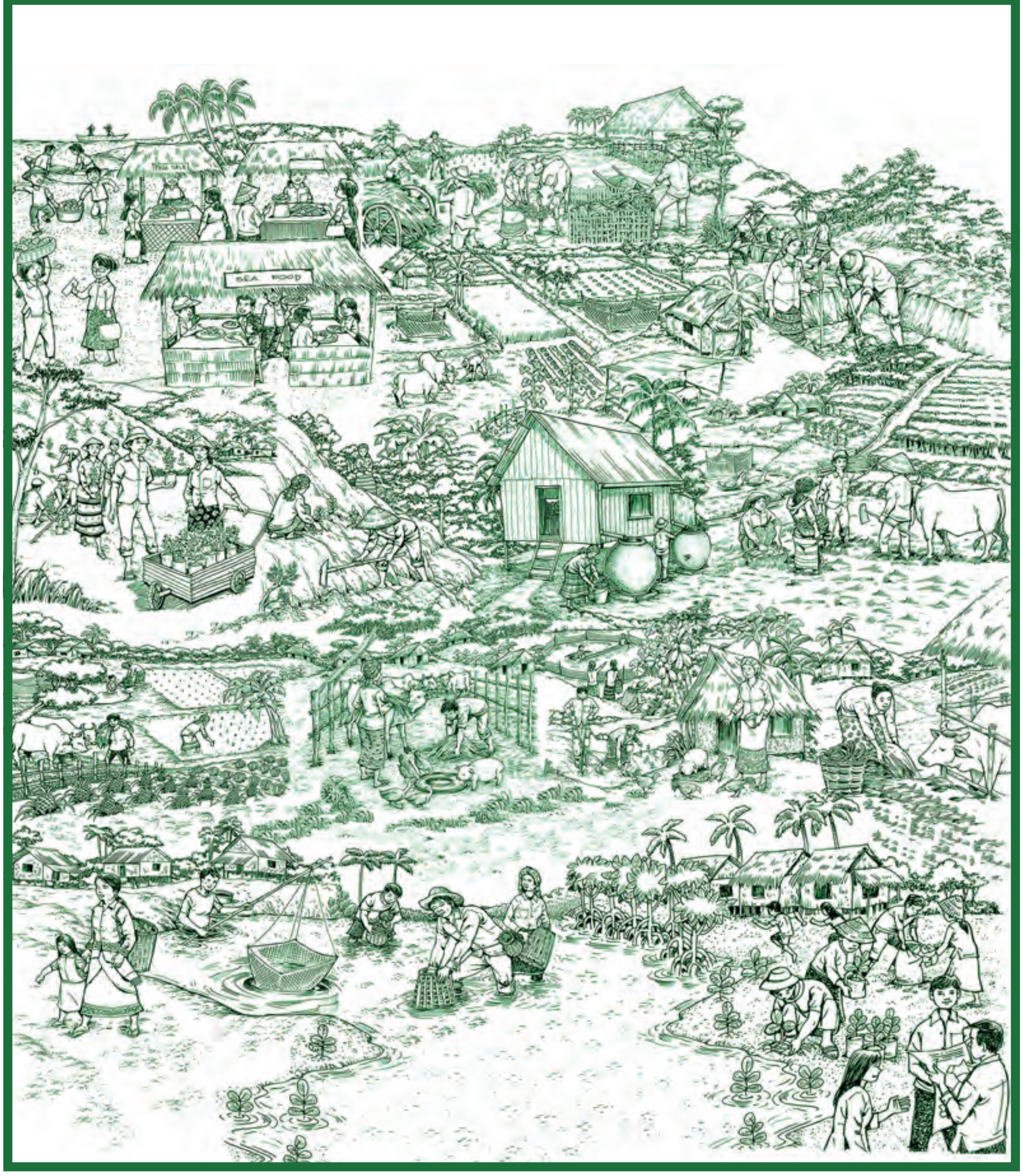
An Overview for Decision-makers



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RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security
CCAFS

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DISCLAIMER:

Foreword

Bridging the gap between the application of research for development (R4D) outputs and their understanding by policymakers and decisionmakers is crucial to the achievement of development outcomes. This gap continues to plague the R4D community and those who are mandated to prepare the adaptation and mitigation policies and plans in many countries. The optimum utilization of R4D outputs is of particular importance as we shift from incremental to transformative approaches to climate change.

This sourcebook includes selected climate-smart agriculture practices and technologies that have been demonstrated to improve adaptation, increase productivity, enhance livelihoods, and contribute to sustainable development under climate change. By covering a wide array of topics – crops, fisheries, livestock, forestry, water, biodiversity, soil, and landscapes – the sourcebook features many entry points to climate-smart agriculture (CSA) and its diverse range of players. It also positions CSA as a holistic and integrative approach.

Viewed from several and sometimes divergent perspectives, the sourcebook also includes results of important analyses and responses on the impacts of climate change. Likewise, it features country profiles, responses, and links with disaster readiness and response (DRR) to climate change, nutrition, and gender.

Aside from policy and decision makers, this sourcebook is also a good reference for technical and other readers who would like to learn more about CSA and how they could effectively respond to climate change. Moreover, this also a useful reference in training and teaching as well as a source of ideas for planners and programmers of rural development.

I would therefore like to commend Dr. Julian Gonsalves and other editors and authors of this sourcebook for reporting important research results, and sharing some of the best of previously published work in a simplified or a shortened form. These articles provide local decision-makers with ideas for possible upscaling in Southeast Asia. I enjoin all those interested in finding ways to enhance resilience of farmers and fishers to read this sourcebook.

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Introduction

Southeast Asia is a rapidly growing region on the frontlines of the battle against climate change. As one of the most vulnerable regions in the world, hundreds of millions of people are at risk as increasing temperatures, flooding and rising sea levels threaten livelihoods, incomes and food security. The region is home to some of the world's most spectacular natural and cultural diversity.

Yet rapid economic expansion and the growth of megacities and agricultural land are encroaching are into these areas. Changes in climatic patters are not only expected to negatively impact agricultural yields and biodiversity. They will also drive changes within communities - indirectly by affecting healthcare and social service provisions, and directly by affecting the land that communities currently farm.

The challenges ahead for decision makers include balancing economic growth with food security concerns, while safeguarding long-term social and environmental equity and sustainability. They also include ensuring that agricultural and social security systems alike are robust enough to respond to future climatic shocks. At the same time, communities will need to adapt to the immediate impacts of climate change, while mitigating future impacts.

This sourcebook is a guide for those who need to assess trade-offs and weigh up key challenges presented by climate change, to make more effective and informed decisions. It gathers a rich pool of literature from over 700 papers condensed into these pages, underpinned by cutting-edge science, to provide succinct, relevant and timely information about climate challenges - and potential solutions.

As climate change impacts each region of the world differently based on topographical and ecological contexts, the papers in this sourcebook provide an overview of climate-smart practices, technologies and approaches from around the world. While the focus of the sourcebook is on challenges specific to Southeast Asia, the solutions may come from, or already have been tested elsewhere. It is for this reason that these papers have been included.

Of all the challenges presented by climate change, one of the biggest is uncertainty. The lack of certainty about how climate change will impede or impact economies and communities that drive them, reduces our ability to respond effectively. But it is for this reason that planning is critical. This sourcebook is intended to provide a sound foundation of knowledge, outlining what we know about climate change, and what measures might be taken to mitigate its most harmful impacts.

This sourcebook is designed to address a broad scope of issues under the topic of agriculture, including biodiversity and genetic erosion and diminishing natural resources. It also examines the potential consequences of these changes, food system sustainability, gender relations and inequality, and social security safety nets—particularly during natural disasters and emergency situations.

As we prepare for the challenges ahead, this sourcebook provides the resources to obtain a clear grasp on some of Southeast Asia's most pressing challenges related to agriculture and climate change, so that we may tackle them effectively for future generations. We hope that it is a valuable resource.

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Why and how this sourcebook was produced

Climate-smart agriculture is increasingly recognized as an important pathway to addressing food security in the context of a changing and unpredictable climate. Climate-smart agriculture is one way to address both the short- and long-term agricultural priorities in the face of climate change. Policy makers, planners, and researchers have to find ways to increase agricultural productivity in an environmentally friendly way, and in a manner that helps households and food systems adapt to climate change, all the while reducing emissions from agriculture.

Researchers and local administrators, including those supported by the Climate Change, Agriculture and Food Security (CCAFS) of the Consultative Group on International Agricultural Research (CGIAR) in Southeast Asia, have been provided a special opportunity to identify, develop, and advocate technological, institutional, and policy options for farmers in Vietnam, Laos, and Cambodia as well as other Southeast Asian countries.

Agricultural intensification that is both environmentally friendly and sustainable requires that key players have a shared understanding of the premises and frameworks involved. Fortunately, a vast reservoir of science-based knowledge is already on the shelf. What remains to be done to increase the uptake of already available climate-smart agriculture (CSA) is to render the information in ways that make it accessible and easily understood by decisionmakers in governments and those who deliver outcomes on the ground.

This sourcebook features materials from a diverse range of organizations and projects, thus demonstrating the wide constituency that supports the search for adaptation options in smallholder agriculture. The target groups for this sourcebook are key decisionmakers in government, local research administrators, and civil society partners. Working on this sourcebook was initiated in mid-2014. Desk research was undertaken over a period of eight months, and over 700 sources (mostly Asia-relevant) were unearthed. Those articles that were deemed most relevant to the target audience were chosen. These were further shortlisted and a second search was done to identify information gaps. Only 65 articles were selected from the wider pool and these appear here in this collection. Some articles were repackaged for purposes of simplification but no rewriting was done.

The selected articles were shortened by a team based in the Philippines, then provided with illustrations and basic layout. A team of artists, an editor, and graphic designers were engaged. An advisory group met in November 2015 in the Philippines to do a final review and to discuss the clustering into relevant chapters. The process was reported and feedback sought at the CCAFS coordinating meeting held in Hanoi in November 2015. A complimentary set of posters with key messages derived from the articles in the sourcebook were also developed.

A second sourcebook featuring specific technologies and practices in Vietnam, Laos, and Cambodia is planned for 2016. It will be based on primary research outputs emanating from CCAFS work in the region and from the Climate-smart villages supported by CCAFS.

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Contents

chapter 1

Climate risk in Southeast Asia

- Overview on natural disasters in the Asia-Pacific region
- Impacts of climate change in Southeast Asia
- Rethinking agriculture in the Greater Mekong Subregion (excerpts)
- Drivers of change in livelihood sectors in the Mekong
- Overview of livelihood sectors in the Lower Mekong basin (LMB)
- Towards an enabling environment for advancing disaster risk reduction and climate change adaptation
- Implication of climate change for rural development programs
- Making climate-smart agriculture work for the poor
- Climate constraints to the agricultural sector
- Vietnam climate change vulnerability profile
- Impacts of climate change on Vietnam fisheries
- LAO PDR Climate change vulnerability profile
- Cambodia climate change vulnerability profile

Climate risk in Southeast Asia

Southeast Asia is on the frontline of efforts to combat climate change. As one of the most vulnerable regions in the world, hundreds of millions of people face increased livelihood risks from flooding, famine and rising sea levels. The countries of the region, spread across archipelagos, river basins and forests, are home to some of the world's most spectacular natural and cultural diversity. Yet climatic changes are expected to negatively impact agricultural yields, biodiversity, forest harvests, and availability of clean water, as well as human and environmental health in this diverse region. Given Southeast Asia's intensive economic development plans, the growth of megacities and spreading agricultural land, this is a critical time to ensure that economic growth is balanced with conversion and efforts to mitigate as well as adapt to the impacts of climate change. This chapter examines the challenges facing Southeast Asia, highlighting disaster risk reduction and climate change adaptation efforts to minimize negative impacts of climate change.

Overview on natural disasters in the Asia-Pacific region

Asia and the Pacific is the most disaster-prone region in the world. Geologically, the region is characterized by active tectonic plate movements in the Pacific and Indian Oceans, which have been the source of major earthquakes and tsunamis. The Indian and Pacific Oceans also regularly generate tropical cyclones and typhoons. The region is home to young mountain ranges which are especially prone to earthquakes, landslides, flash floods, avalanches and Glacial Lake Outburst Floods (GLOFs). Geographically it is a region of physical diversity with islands, mountains, extensive coastlines, forests, deltaic plains and deserts. The weather and climate systems are driven primarily by monsoon variability and snow cover dynamics, which both contribute to the frequency and severity of floods and drought. Several major rivers flow through the region, often across several national borders, and a large portion of the population lives in the fertile valleys of these rivers.

This article was drawn from the introductory sections of a report entitled *Overview of Natural Disasters and their Impacts in Asia and the Pacific*, 1970 – 2014 produced by ESCAP. This article was edited to present a shortened overview of natural disasters in the Asia-Pacific region with some discussion of impacts. For more detailed discussions, refer to the original publication mentioned in the source box found at the end of the article.

In the past decade alone, a person living in Asia-Pacific was twice as likely to be affected by a natural disaster as a person living in Africa, almost six times as likely as someone from Latin America and the Caribbean, and 30 times more likely to suffer from a disaster than someone living in North America or Europe (ESCAP: 2013). News reports on natural disasters in the region has been ceaseless.

Since 1970, the region has been hit by more than 5000 disasters causing more than two billion fatalities and affecting the lives of more than six billion. The worst disaster in terms of loss of life occurred in 1970, when Cyclone "Bhola" struck Bangladesh and caused a storm surge that killed 300,000 people and affected 3.6 million more. Around twenty years later when a more severe cyclone struck the same region in Bangladesh, 138,000 people died and 15 million people were affected, becoming the second largest storm with respect to fatalities, though notably less people died due primarily to disaster risk management efforts in the country. Cyclone "Nagis" killed a similar number of people in Myanmar in 2008. Storms and floods are annual events in some parts of the region. The Philippines is often devastated by typhoons, including the Super Typhoon "Haiyan" in November 2013 which killed over 6,000 people and displaced approximately 4 million people (NDRRMC: 2014).

Earthquakes and tsunamis have wrought devastation over the period, with some of the worst events being the 1976 Great Tangshan Earthquake which killed almost 242,000 people in China, the 2004 Indian Ocean Tsunami that killed over 220,000, and, more recently, the 2011 Great East Japan Earthquake that killed almost 20,000 people and affected the lives of around 369,000.

There are many social, economic and environmental factors that determine the vulnerability, exposure and impact of a disaster on people or a country. Over the past 45 years, the region's population has almost doubled from 2.2 billion in 1970 to 4.3 billion in 2014. Cities have expanded with the migration of people from rural areas in search of livelihoods and opportunities, with 47.7 per cent of the population of Asia-Pacific now living in cities compared to only 25.9 per cent in 1970. Often the poor and the most vulnerable settle in hazardous areas such as flood plains or along fault-lines because the land is more affordable or it is the only land available in densely populated areas. Over time, vulnerable populations' exposure to disasters has increased.

Likewise, economic development has been rapid in many countries of the region. As economies grow, so does the value of the infrastructure and assets that could potentially be destroyed by a disaster. These assets are increasingly located on land exposed to hazards due to a lack of available space and rapid development, and thus potential economic exposure has also increased over time.

Other changes over the past 45 years should also be considered as possibly affecting statistical trends. Disaster events are now more regularly and accurately recorded than they were in 1970. The progress towards achieving the Millennium Development Goals (MDGs) and the Hyogo Framework for Action (HFA) has improved the resilience of countries over time, reducing the disaster risks. Also, climate change could already be affecting the intensity and frequency of climatic disaster events in some countries.

With the Third United Nations World Conference on Disaster Risk Reduction (WCDRR) shortly to begin, and a new disaster risk reduction framework to be agreed upon globally, a brief overview of key statistics, issues and changes over the past 45 years is timely. This overview will highlight the progress made along with the challenges faced by the region.

In recognition of this, the current paper provides a review of natural disasters and their impacts in Asia and the Pacific by disaster type, subregion and level of development. The first section looks at the occurrence of natural disaster events. This is followed by an analysis of fatalities and economic loss in sections two and three respectively. The short-term consequences of natural disasters on the economy are also mentioned. The final section briefly discusses aspects regarding exposure and vulnerability of countries in Asia and the Pacific.

Occurrences of natural disasters

Overview of occurrences

From 1970 to 2014, the world reported a total of 11,985 natural disaster events, of which 5,139 (or 42.9 per cent) took place in Asia and the Pacific (Figure 1.1). Floods and storms were the most frequent in the region, accounting for 64 per cent of the total number of such events reported between 1970 and 2014. This was followed by earthquakes and tsunamis (12 per cent) and landslides (6.9 per cent) (Figure 1.2).

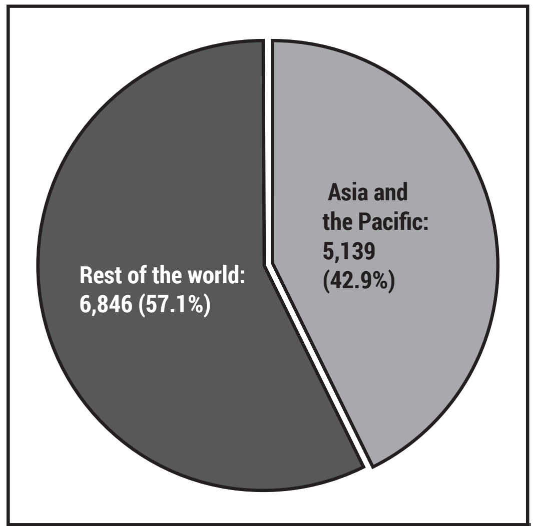


Figure 1.1. Total occurenceof Natural Disaster Events (1970-2014).

South and South-West Asia witnessed the largest number of natural disaster events with 1,652 cases reported. South-East Asia and East and North-East Asia also reported over 1,000 events. The Pacific and North and Central Asia had significantly lower numbers of reports (Figure 1.3). Disasters have been reported with increasing frequency in all parts of the region since 1970. However, the numbers of reports on natural disaster events are diverging among ESCAP subregions (Figure 1.4).

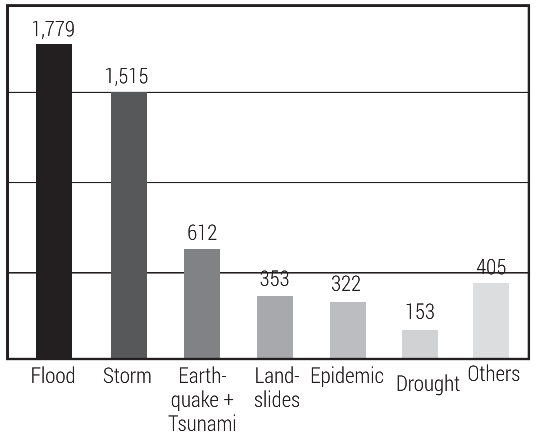


Figure 1.2. Occurence of Natural Disaster Events in Asia and the Pacific by type (1970-2014)

The number of hydro-meteorological disasters quadrupled from 37 per year in 1970-1979 to 146 per year in 2000-2009, while reports of geophysical natural disaster events substantially increased as well during the same period (Figure 1.5). Floods and storms, the most frequent events recorded in

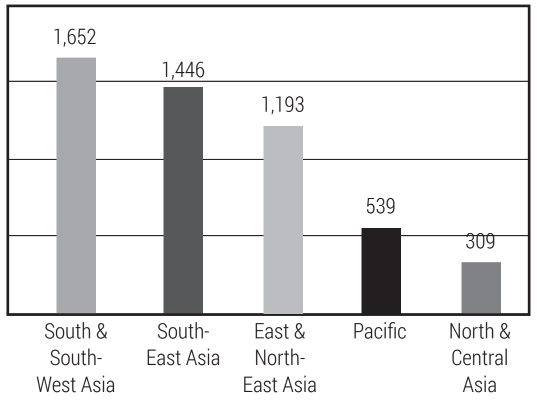


Figure 1.3. Occurence of Natural Disaster Events in Asia and the Pacific by Subregion (1970-2014)

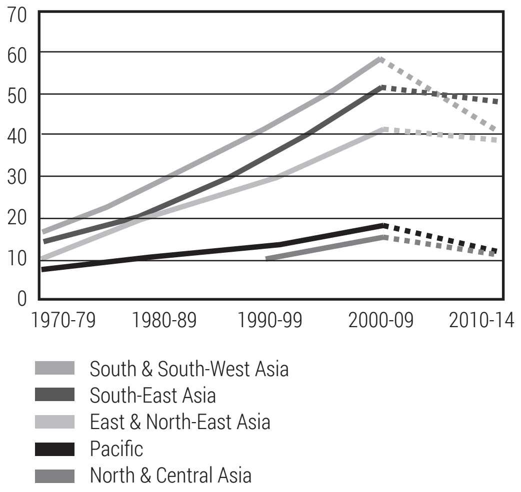


Figure 1.4. Average Yearly Occurences of Natural Disaster Events in Asia and the Pacific by Subregion (1970-2014)

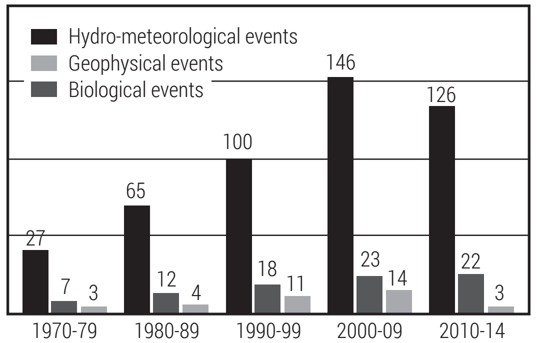


Figure 1.5. Occurence of Natural Disaster Events in Asia and the Pacific by Category

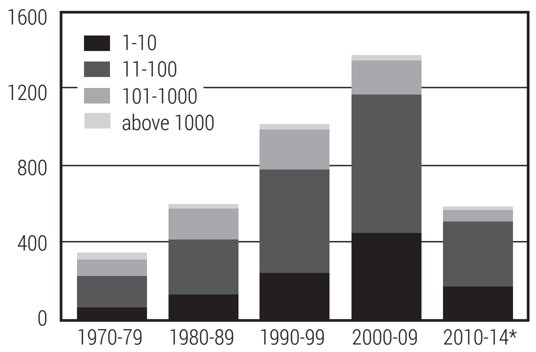
the region, represented two of the highest increases in occurrence. In particular, reports on flooding soared over sixfold from 11 events per year in 1970-1979 to 72 events per year in 2000-2009.

However, these are mostly from the increase in numbers of small and medium scale disaster events. While the frequency of disaster events with more than 100 fatalities have not changed very much, the number of small and medium scale disasters have surged significantly between the 1970s and recent years (Figure 1.6). Also, it should be noted that these increases are partly due to improvements in reporting capacity and practices.

Fatalities from natural disasters

Overview of fatalities

In Asia and the Pacific, a significant number of people lost their lives from natural disasters over the past 45 years. As mentioned earlier, the region was only hit by around 43 per cent of the disasters experienced globally, but the impact of these disasters in terms of lives lost was notable.



*The last column represents only 5 years of data.

Figure 1.6. Occurence of Natural Disaster Events in Asia and the Pacific by Number of Fatalities

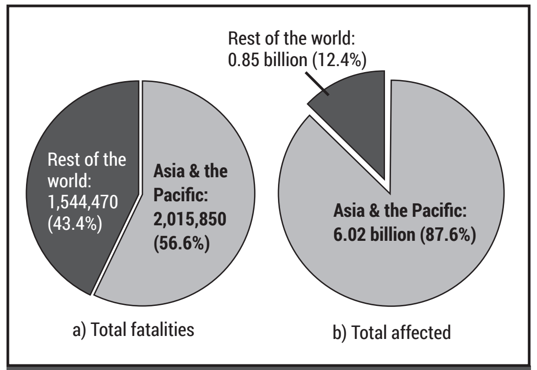


Figure 1.7. Total Fatalities & Affected from Natural Disasters (1970-2014)

Between 1970 and 2014, more than 2 million people died, accounting for 56.6 per cent of the total deaths in the world due to disasters (Figure 1.7).

The impact and susceptability of Asian and Pacific countries to disasters is evident when considering the total number of people affected. Over 6 billion people in the region have suffered from natural disasters, accounting for 87.6 per cent of the global total. Among the fatalities in the region, 45.5 per cent were from earthquakes and tsunamis, as can be seen in Figure 1.8, while storms accounted for 36.8 per cent. Floods and droughts were not the deadliest natural disasters but have affected the largest number of people over the last 45 years — approximately 5 billion.

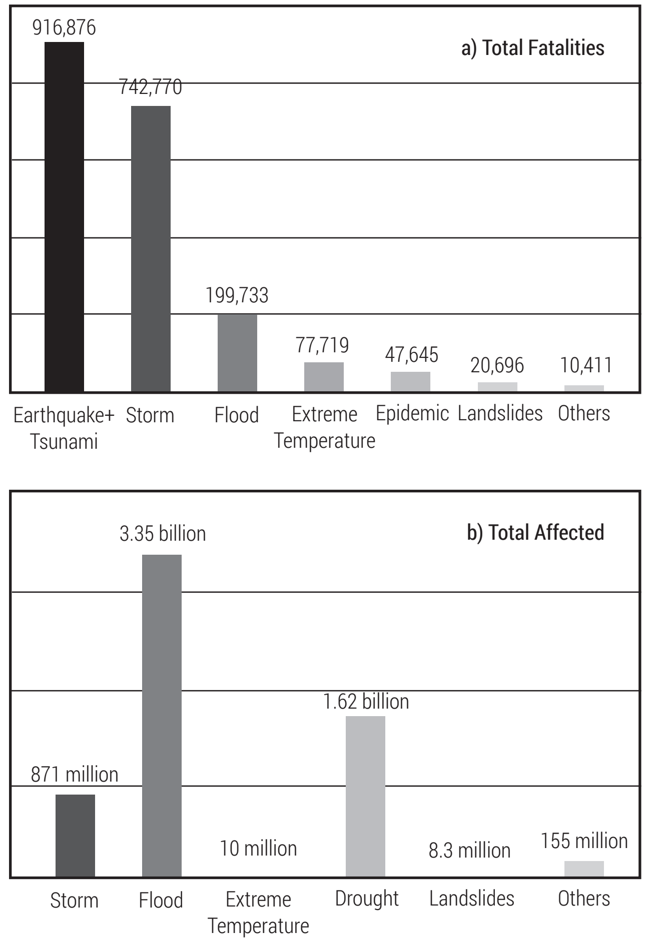


Figure 1.8. Total Fatalities and Affected from Natural Disasters in Asia and the Pacific by Type (1970-2014).

Reference

National Disaster Risk Reduction and Management Council (NDRRMC), Republic of the Philippines. (2014). NDRRMC Update: Updates re the Effects of Typhoon "YOLANDA" (HAIYAN). 17 April.

Source: Overview of Natural Disasters and their Impacts in Asia and the Pacific, 1970 – 2014

By: United Nations Economic and Social Commission for Asia and the Pacific
ESCAP Technical Paper
Information and Communications Technology and Disaster Risk Reduction Division

March 2015

Impacts of climate change in Southeast Asia

Climate change as a key risk to economic development

Climate change in Southeast Asia is expected to lead to significant variations in precipitation patterns, increased incidence of severe weather events, higher temperatures, and sea-level rise in many highly populated coastal regions. These changes will negatively impact agricultural yields, biodiversity, forest harvests, and availability of clean water. It will also lead to a greater incidence of diseases such as malaria and dengue fever. An increased demand for energy and water could strain the ability of urban infrastructure systems to deliver essential services. These impacts cumulatively could slow economic development, causing economic losses of $230 billion, or an equivalent of 6.7% of gross domestic product (GDP) each year by 2100—more than twice the global average loss of 2.6%—and endanger the livelihoods of millions of people.

This article was drawn from previously published material entitled *Climate Change in Southeast Asia: Focused Actions on the Frontlines of Climate Change* by Asian Development Bank. Refer to the source box towards the end of this article for a complete reference to the longer and more detailed publication.

Water resources

The region is increasingly subject to floods and susceptible to stronger tropical cyclones and storm surges. Extreme weather events are expected to increase in intensity and frequency, causing extensive damage to property, productive assets, human life, and livelihoods. Flooding in low-lying populated areas such as coastal regions and river basins will affect farmland and settlements, and damage infrastructure such as roads and bridges. During the dry season, prolonged droughts are a concern, particularly during El Niño years, with longer summers, rising temperatures and less rainfall decreasing water levels in rivers, dams, and other reservoirs. This leads to crop failure, and imperils food security and water availability for consumption, irrigation, and hydropower generation in areas where demand pressures from society are increasing. The Intergovernmental Panel on Climate Change (IPCC) warns that Southeast Asia is particularly vulnerable to sea-level rise and changes to its water resources regime. Without urgent action, mean temperatures could rise by 4.8°C and sea level by up to 70 cm by 2100 from 1990 levels. A projected 40-cm sea-level rise by 2080 could force up to 21 million people in the region, including about 10% of the residents in the Mekong Delta (Institute for Global Environmental Strategies, 2008), to be displaced. Sea-level rise will also cause saltwater intrusion into coastal and groundwater resources, threatening supplies of fresh water for drinking and irrigation.

Agriculture and ecosystems

The region has about 115 million hectares of agricultural land planted mainly to rice, maize, oil palm, natural rubber, and coconut. It is a major producer and supplier of grains and the largest producer of palm oil and natural rubber in the world. Increasing heat and water stresses, extreme weather events, and climate-associated pests and diseases have all contributed to the decline in agricultural production potential in many parts of the region. Thousands of hectares devoted to rice production have been damaged by frequent flooding in the Red River Delta, Central Region, and Mekong Delta. Rising sea levels have accelerated salt water intrusion in agricultural areas, causing considerable loss in arable lands. Consequently, the decline in grain production and industrial crops will impact the livestock industry and other emerging industries that depend on natural resources. For example, by 2100, higher temperatures are likely to cause rice yield potential to decline by up to 50% on average compared to 1990 levels, prompting conversion of even more land to agriculture.

These effects are exacerbated by the need for an even greater increase in agricultural production to meet increased demand for food. ADB estimates that in order to supply the domestic and foreign markets, the region must increase rice production by an average of 2.5% per year and double palm oil production. This intensification of agricultural production will lead to both the conversion of land for cultivation and competition with industry and urban areas for water needed to maintain aquatic ecosystems.

Forest resources

Southeast Asia, with 203 million hectares of forests, accounts for 5.2% of the global total. Expansion of large-scale commercial crops is a significant driver of deforestation in the region, especially as food grain prices rise and oil palm cultivation grows to meet the rising demand for biodiesel. In the early 2000s, about 3 million hectares of peat land in Southeast Asia had been burnt, releasing between 3 to 5 petagrams of carbon (PgC). Draining of peat lands has affected an additional 6 million hectares and released a further 1 to 2 PgC.

Current climate extremes have contributed to an increase in disasters such as fires, landslides, floods, and droughts, which have in turn affected these forests. Over the past 20 years, forest fires have intensified and spread over larger areas. This is attributed largely to the combined effects of rising temperatures, declining rainfall, and more aggressive land use change. In the region, the rate of deforestation among natural forests is faster than in planted forests. This is even more damaging since natural forests have greater carbon sequestration potential and provide more ecosystem services than monoculture planted forests. In some parts of the region, climate change could also trigger the replacement of subtropical moist forests by tropical savannah and shrub lands with low or no carbon sequestration potential. The region is home to some of the planet's most endangered wild species, in addition to hundreds of newly discovered species. Endemic flora and fauna are vulnerable to all these stresses due to loss and disturbance of their habitats.

Managing land use and forests for carbon sequestration

Greenhouse gas emissions from deforestation and land use change are the region's major contributor to global climate change. Southeast Asia offers many low-cost opportunities for greenhouse gas mitigation in the land use, land-use change and forestry (LULUCF) sector, demonstrating the greatest potential for reducing global emissions (by about 40% in Indonesia, Philippines, Thailand, and Vietnam for 2000–2050). The IPCC also reported that the potential for technical mitigation in agriculture was highest in Southeast Asia among all other regions in the world.

Improving forest and agricultural land management is one of the most cost-effective ways to reduce greenhouse gas emissions in Southeast Asia. ADB is encouraging countries to conserve forests, reduce land degradation and restore peat lands, and is helping them prepare for Managing land use and forests for carbon sequestration and gain access to climate financing, or incentives such as Payments for Ecosystem Services (PES), in exchange for improved management practices.

Through loans and technical assistance, ADB helps countries maximize opportunities to secure people's livelihoods from climate impacts, plus supplement incomes with new sources of revenue from carbon sequestration. In the region, ADB will collaborate with other donors to implement innovative initiatives such as the Forest Investment Program (FIP) and carbonneutral transport corridors in the Greater Mekong Subregion, support preparation of additional projects for the Forest Carbon Partnership Facility of the World Bank, and implement readiness projects on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD).

Coastal and marine resources

Rising temperatures and sea levels, and extreme weather events threaten to severely impact coastal and marine resources, and the industries and activities that rely on them. In 2005, the estimated population living within 100 km of the coast reached about 452 million people, equivalent to about 79% of the region's total. Fully one-third of the inhabitants within the Coral Triangle—more than 120 million people, particularly those living in coastal communities—depend directly on local marine and coastal resources for their income, livelihoods, and food security. Coastal aquaculture has been the most important fishery activity in Southeast Asia, with more than 30,000 households spread over 64,000 hectares earning a livelihood from shrimp farming. Rising temperatures also lead to a reduction in fish production, threatening the entire region's potential as the world's largest producer of fish and marine products.

Marine ecosystems are highly vulnerable to climate change. Warmer temperatures are leading to increased rates of coral bleaching or the loss of the normal healthy color of the corals, owing to the breakdown of the symbiotic relationship between corals and the algae that provide it with food. Climate change will also likely contribute to the gradual destruction of mangrove vegetation, coastal sea life, and degradation of prized tourism destinations, thus threatening major economic activities. Advancing sea levels and coastal erosion are causing mangrove forests to retreat in order to maintain their preferred environmental conditions. The IPCC projected that with a 1 meter rise in sea level; about 2,500 square kilometers of mangroves in Asia are likely to be lost.

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Rethinking agriculture in the Greater Mekong Subregion

Southeast Asia's agriculture is shifting from traditional subsistence farming to modern commercial farming practices. Although individual countries and subnational regions are progressing at vastly different paces, they are generally following a path of intensification, specialization, increased agrochemical use and mechanization. Trends observed in the more developed nations, such as Thailand and China, are likely to emerge in the less developed countries in future.

The increase in crop production reflects the farmers' adoption of 'green revolution' approaches and technologies rather than land expansion. These approaches include more effective irrigation, improved plant varieties, increased use of fertilizer and better farming practices. The increased production of 50% from small livestock, 45% from cattle, 300% from brackish-water aquaculture and 500% from freshwater aquaculture is a consequence of intensification and an increase in the production area.

This article was drawn from previously published material entitled *Rethinking agriculture in the Greater Mekong Subregion: how to sustainably meet food needs, enhance ecosystem services and cope with climate change* by Robyn Johnston, Chu Thai Hoanh, Guillaume Lacombe, Andrew Noble, Vladimir Smakhtin, and Diana Suhardiman from IWMI; and Kam Suan Pheng and Choo Poh Sze from WorldFish Center. Refer to the source box towards the end of this article for a complete reference to the original article.

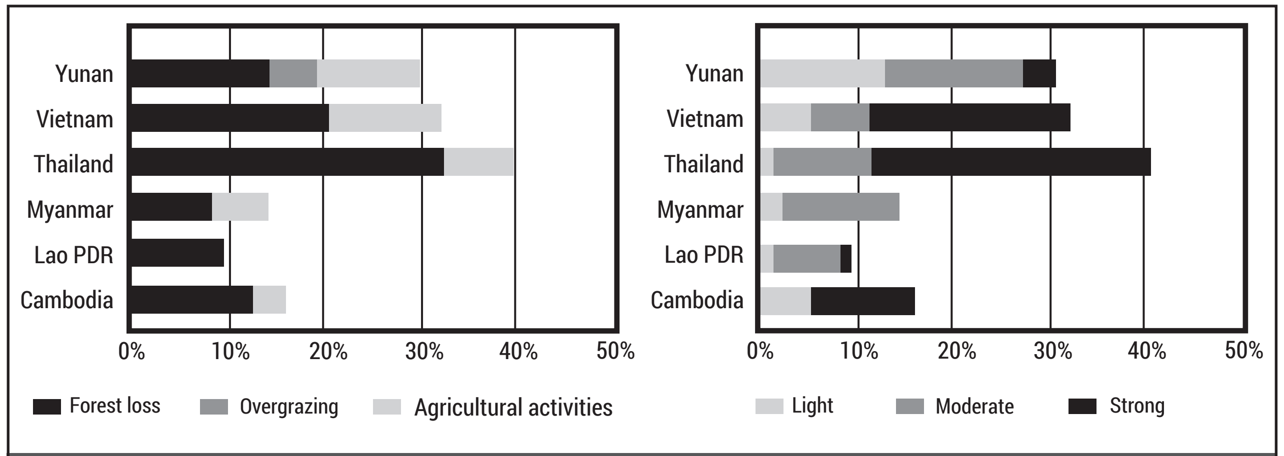

Figure 1. The extent and cause of land degradation in the GMS. Source: UNEP and TEI, 2007

These dramatic production rises have come at an environmental cost. According to the Greater Mekong Environment Outlook, land degradation affects between 10 and 40% of land in each country in the GMS (Figure 1). Forest loss, agricultural intensification and overgrazing (in Yunnan) are the main causes for this. Changes to artificial landscapes associated with farming activities have disrupted vital natural services by reducing the capacity of ecosystems to contain floods, control erosion and limit damage from pests.

Agriculture is the largest user of water in all countries in the GMS, consuming between 68 and 98% of total withdrawals. By altering natural flow regimes, irrigation development has affected fish populations and wetland habitats. Resulting dry-season water shortages have increased competition for water, especially in intensively-irrigated areas such as Vietnam's Red and Thailand's Chao Phraya deltas. Hydropower schemes planned for the Mekong, Salween and Irrawaddy rivers will disrupt natural flows further, with implications for farming and fisheries. Blocking migration paths with dams, for example, prevents fish reaching spawning and feeding areas.

Features of the Greater Mekong Subregion

The GMS comprises five agroecological zones that have common farming systems and are subject to similar geographical constraints and risks. The zones are not rigidly defined, but provide a helpful way to discuss agricultural systems at a regional scale.

Deltas and Tonle Sap floodplain

The Tonle Sap floodplain and mega-deltas of the Red, Mekong, Chao Phraya and Irrawaddy rivers represent around 8% of the total GMS land area, but house over a third of the total population, some 86 million people. Rural population densities are high, and each delta hosts a major city. These cities offer opportunities to farmers, providing markets through demand for horticultural crops and meat, and alternative income sources. The deltas are the rice bowls of the countries, but are nearing full production, with problems of intensification, flooding and high population density.

The deltas represent a range of development from the Tonle Sap floodplain and Irrawaddy River, with limited irrigation and lower populations, to the densely settled, intensively farmed Red and Chao Phraya deltas, producing two or three crops a year. The Red, Mekong and Chao Phraya deltas have highly developed irrigation infrastructure (dykes, levees and canals to divert and retain water), but they all suffer water shortages in the dry season. For example, in the Mekong Delta in Vietnam, more than 80% of dry-season flows are diverted for irrigation, resulting in local water shortages and seawater intrusion.

Rice is the major crop; the deltas produce almost half of the GMS's rice. Although it is likely to remain the dominant crop, some deltas are beginning to grow a wider range of produce. For example, only 60% of land in the Chao Phraya Delta is now planted with rice; one million hectares (Mha) of alternative crops, mainly sugarcane and cassava, are grown, primarily for export. In the Red River Delta, 40% of land produces non-rice crops in the winter. The by-products of rice farming support large herds of cattle, buffalo, pigs and poultry.

The deltas support extensive marine and inland capture fisheries, as well as rapidly expanding brackish and freshwater aquaculture. The Mekong Delta accounts for 70% of Vietnam's aquaculture production and 63% of its marine capture. The Tonle Sap floodplain is particularly important because of its productivity and link to the inland fisheries of the Lower Mekong Basin, including Cambodia, Lao PDR and Vietnam. Here, inland capture fisheries dominate; and aquaculture is minimal.

Lowland plains and plateaus

Lowland plains and plateaus make up a quarter of the GMS and house 64 million people. Apart from sparsely populated northern Cambodia, population densities are moderate and poverty is widespread. The plains and plateaus represent a development trajectory from the forests growing in northern Cambodia through the partially irrigated extensive agriculture of the Isan Plateau to the highly irrigated Central Thai Plain.

Agriculture is mostly rain-fed, although annual rainfall is generally low. Lowland plains and plateaus produce a quarter of the GMS's rice, mostly in the wet season. In the dry season, farmers supplement wet-season rice by grazing livestock on the rice stubble, planting a second crop of irrigated rice, or growing irrigated sugarcane, maize, legumes, pulses or cassava. Large livestock herds of cattle and buffalo graze the plains and plateaus. Cattle are progressively replacing buffalo due to mechanization and dietary preferences for beef.

Large-scale plantations of oil palm, rubber, eucalypt, sugarcane, cassava and other industrial crops are increasing on the plains and plateaus. For example, by 2007, Lao PDR had granted concessions to 123 large plantations covering 165,794 ha. Sixty percent of these were located in the lowland plains of central and southern Lao PDR.

Wild-catch fishing on inland rivers, lakes and reservoirs is important to rural populations, especially in Cambodia, Lao PDR and northeast Thailand. However, experts fear hydropower developments on the Mekong and its major tributaries will disrupt migrations of species on which people in Lao PDR and Cambodia depend. Thailand and Myanmar, meanwhile, have reported increases in fish production in recent years. These are a consequence of improvements in managing aquatic resources, such as restoring and rehabilitating damaged environments, and restocking lakes and reservoirs.

There is minimal infrastructure on the plains of north and northeast Cambodia but all other GMS countries have invested heavily in irrigation; Cambodia, too, has ambitious plans to install irrigation infrastructure. Thailand's Chao Phraya Basin is highly developed with two large water storages and thousands of small dams and reservoirs. Around one-third of this 2.4 Mha command area is on the Central Plain. In Isan, several large hydropower-irrigation schemes and some 20,000 smaller schemes service an irrigable area of 1.4 Mha. Serious water shortages in both basins in the dry season prompt conflicts between urban, industrial and agricultural users.

Irrigation has expanded in Myanmar since the 1980s and now covers a quarter of the cropped area. Large-scale schemes are concentrated in Sagaing, Mandalay and Bago provinces. Smaller river-pumped, reservoir, river diversion and private village-based schemes make up the rest. In Lao PDR, more than 4,000 small to medium-sized schemes pump water from rivers. This irrigation infrastructure covers 190,000 ha during the wet season and 136,000 ha in the dry season. The government aims to double the irrigated area by 2020.

Lowland plains have been largely cleared for agriculture in Thailand and Myanmar, with the remaining native vegetation limited to higher, steeper land. Significant stands of forest remain in northeast Cambodia and southern Laos. These could potentially be converted to farmlands. However, poor soils are widespread, access to water is limited and the remaining forests have significant conservation value.

Coastal zones

Narrow coastal plains rising rapidly to coastal ranges of 500 to 2,000 m make up 10-15% of Thailand, Myanmar and Cambodia, and over a third of Vietnam. Coastal rivers tend to be short and steep, with small watersheds.

Coastal zones exhibit a range of agricultural systems, from paddy rice to rain-fed field crops (legumes, cassava, sugarcane and peanut), tree crops (fruit, nuts, eucalypt for paper pulp, jatropha and rubber), intensive cattle and pig farming, plus vegetable production. With farm sizes small and grazing areas limited, there has been a shift towards raising livestock intensively in combination with growing crops. Small-scale irrigation of rice and vegetables using rivers and groundwater takes place on the floodplains of coastal rivers. Plantations account for a quarter of the cropped area.

The coastal zones of all countries are important for capture fisheries, with annual landings estimated at 2.2 million tonnes (Mt). Marine fishing is mostly restricted to the shallower parts of coastal shelves. Large numbers of small-scale artisanal fishers catch multiple species, but large-scale commercial fisheries are dominated by non-local and foreign investors. Overfishing has prompted a consistent decline in the catch per unit effort. Marine- and brackish-water aquaculture is limited in non-deltaic coastal areas but there are opportunities for developing specialized culture systems in the cleaner waters along exposed coastlines.

Significant areas of forest remain in coastal parts of Myanmar and Cambodia but rates of deforestation and mangrove clearance are high. Little natural forest cover remains in Thailand, as a result of conversion to plantations since the early 1900s. Significant areas of forest remain in Vietnam but logging and thinning have taken their toll.

Erosion in the coastal uplands is exacerbated by flash flooding along short, steep coastal rivers. The sandy, low-fertile soils of the coastal strip make it hard for farmers to maintain productivity. Urban and agricultural pollutants reduce water quality in nearshore environments close to densely populated parts of Vietnam and Thailand. Pollution and the destruction of mangrove and coral habitats have affected fish stocks in the shallow waters fished by small-scale fishers.

Intensively farmed and forested uplands

Over half of the GMS is hills and mountains. These uplands support 85 million people, of whom 46 million live in Yunnan, China. Two agricultural systems exist: intensive farming of highly productive, densely populated upland river valleys; and shifting cultivation and livestock grazing of sparsley populated forested terrains. This distinction is likely to remain, as large tracts of the forested uplands are steep, with poor, infertile soils. The boundaries between the two will shift as degraded soils return to forests and new lands come into production.

Intensive farming takes place on upland plains and in river valleys, which are often terraced for growing rice. The subtropical climate gives way to temperate conditions at altitude, enabling a wide range of plants to grow. Major food crops include rice, maize, vegetables, wheat and cassava. Important cash crops are vegetables, flowers, tobacco, coffee, sugarcane, tea, rubber, pepper, fruit trees, cocoa and mulberry. Farmers supplement irrigated wet-season rice with dry-season crops of faba bean, wheat, oil seed rape or sugarcane. They also raise livestock semi-intensively. Partial irrigation supports some cash crops including tobacco, vegetables and coffee. Using groundwater to irrigate coffee plantations in Vietnam's Central Highlands has depleted water supplies.

Traditionally, upland farmers derived their livelihoods from shifting or 'swidden' cultivation, livestock farming and by growing a limited number of cash crops. In forested upland areas, two swidden systems endure. 'Established' entails farmers cultivating trees, annual crops, cereals and legumes on a rotational basis, while 'pioneering' or 'slash and burn' involves clearing land and growing monoculture crops of cereals and legumes. The latter requires long fallow periods of 8-10 years, but with increasing population pressure this has decreased to 1-4 years, resulting in erosion and declining soil fertility. Upland fishing is insignificant economically but provides valuable protein to communities.

Concerns about sustainability, the desire to locate populations in areas where services exist and various political and security issues have led all governments to introduce programmes to resettle ethnic minorities and eradicate shifting cultivation. These policies have prompted the expansion of permanent upland agriculture, often in unsuitable areas. Commercial plantations of rubber, timber and oil crops are also increasing, particularly in southern Yunnan, northern Lao PDR and parts of Myanmar. Wild-sourced timber remains an important economic sector in the uplands of Myanmar. A relatively high proportion of forest cover remains in the uplands, but it is shrinking. Rates of loss are high in Myanmar and Lao PDR but have stabilized in Yunnan and Vietnam, where replanting programmes have increased tree cover.

Intensive upland farming causes catchment-wide soil erosion. This decreases soil fertility and overloads waterways with sediment. Inle Lake in Myanmar has shrunk in length from 56 to 15 kilometers (km) during half a century. Plantations also prompt high soil erosion rates unless the understory is maintained.

Climate change and agriculture

Projected climate changes in the GMS Results from studies carried out by IWMI and others in the GMS, anticipate the following main climate changes to 2050.

- Increase in temperature of 0.02 to 0.03 °C per year in both warm and cold seasons, with higher rates of warming in Yunnan and northern Myanmar.
- No significant change in annual rainfall across most of the region, but some seasonal shift in rainfall, with drier dry seasons, and shorter, more intense wet seasons.
- Sea level is expected to rise by 33 cm by 2050 on top of the observed rise of 20 cm over the last 50 years.
- An increase in the temperature of the sea surface may increase the intensity and incidence of typhoons during El Ninõ years.
- The impact of glacier melt is negligible in the two main catchments of the GMS (Mekong and Irrawaddy). The situation may differ slightly in the Salween catchment where the contribution of ice melt to total runoff is higher.

A high level of uncertainty surrounds all these projections, with the exception of those forecasting rising temperatures. The rise in CO^2 emissions between 2000 and 2007 was higher than that predicted by the worst-case scenario of the Intergovernmental Panel on Climate Change (IPCC) and global warming may accelerate more quickly than current models indicate. Projections of rainfall and runoff are so inconsistent that it is counterproductive to use them to shape adaptation strategies until more reliable estimates are available. A better option is to assume increased variability and uncertainty of water availability, and manage water resources cautiously. Long-term changes will be more severe.

Impacts of climate change on agriculture

Climate change has impacts on agriculture.

- Directly, at local scale, due to changes in temperature, rainfall and sea-level;
- At local to subnational scales, through changes in water regimes; and
- Indirectly, at global and GMS scales, by physical, social or economic means, such as sea-level rise, migration or changes in food prices.

Increased temperature: Warmer conditions can reduce yields of crops and pastures by preventing pollination. For example, rice yields decrease by 10% for every 1°C increase in minimum temperature during the growing season.

Increased CO^2: This has a fertilization effect and can increase the yield of some crops (including rice, wheat, grasses and most trees).

Increased pests and diseases: Higher temperatures and longer growing seasons could damage pest populations.

Increased water demand: Higher temperatures will increase evapotranspiration, raising the water needs of rain-fed and irrigated crops and pastures. Scientists believe demand for irrigation in semi-arid regions of Asia will increase by at least 10% per 1°C temperature rise. The water needs of livestock will also rise.

Change in viability of crops: Changes to temperature and rainfall may require farmers to use new varieties or alter cropping patterns.
Vertical shifts in ecosystems: Average annual temperature decreases by about 1°C for every 100 m of elevation in tropical to subtropical areas. Some vertical shifts in ecosystems are likely as temperatures rise, particularly on the Tibetan Plateau and in the montane regions of Yunnan.

Changes to seasonal timing: Shifts in the onset, and end of, the wet season may affect crop yields and irrigation demand (positively or negatively, depending on the crop calendar).

Extreme climate events: These are likely to become more frequent.

Sea-level rise and saltwater intrusion: Rising sea waters will reduce viable crop areas in the deltas and along coasts; saline intrusion already affects 1.4 Mha in the Mekong Delta. Further rises in sea-level will require adaptation measures to protect crops. In the longer term, if the current situation is maintained, sea-level rise could have catastrophic impacts on deltas and coastal areas.

Impacts on fisheries: Climate changes will likely affect the metabolism, growth and distribution of many aquatic organisms, as well as influencing diseases that afflict them. Fisheries are vulnerable to reduced dry-season flows; these could dwindle further as temperatures rise. Changes to wild fish stocks, particularly of marine origin, will affect supplies of fish meal and fish oils that support the aquaculture and livestock industries. However, coastal and delta areas rendered unsuitable for crop production as sea-levels rise may provide new opportunities for aquaculture.

Changes beyond 2050

Global studies suggest that the rise in temperature will speed up and become nonlinear, and rainfall will increase. Impacts due to climate change to 2100 are projected to be correspondingly much more severe. Experts anticipate that sea-level rise will accelerate to reach at least one meter above current levels by 2100. This will pose a significant threat to coastal and delta regions of the GMS, and demands consideration when planning for the long-term.

Adapting agriculture to climate change Because the rates and timings of climate change are uncertain, it is important to build resilient communities that are able to deal with unforeseen changes. Capacity to adapt to change is very closely linked to socioeconomic factors, such as poverty, diversification of income sources, level of education, and access to infrastructure and technology. Promoting broad-based agricultural development to lift rural communities out of poverty is probably the most effective adaptation strategy available. At a technical level, there is a large body of knowledge about changes in agricultural systems that could help safeguard production. Farmers have always lived with climate variability and have many coping strategies for droughts and floods that will form the basis for adapting to climate change. Many of these adaptation measures are 'no-regrets' responses, which also provide benefits in terms of production or environmental outcomes, including reducing greenhouse gas emissions to mitigate the impacts of climate change (see Table 1, overleaf).

Table 1: Shifting cultivation in the GMS.

Subsector	Response strategy	Adaptation	Mitigation	Environmental impacts or interactions (Red=negative; Black=positive)
Crops	Diversify production systems	x		Reduce monocultures, improve biodiversity, create more resilient systems
	Improve crop varieties	x		Increase yields, reduce pressure for additional farmland
	Intensify agriculture	x		Use more water, fertilizers, pesticides and herbicides. Generate higher methane emissions from paddy in the dry season
	Improve rice cultivation	x	x	Use less water, increase yield, lower methane emissions
	Introduce biofuels (irrigated/annual crops)		x	Extract more water, increase demand for agricultural land creating competition with food crops
	Introduce biofuels (dryland/perennial crops)	x	x	Increase vegetation cover and carbon storage. Increase demand for agricultural land, creating competition with food crops
Water	Practice reduced- and zero-tillage farming	x	x	Enhance carbon sequestration, restore soil fertility, rehabilitate degraded land
	Expand dry-season irrigation	x		Extract more water
	Introduce supplementary wet-season irrigation	x		Extract more water but not as much as that used by dry-season irrigation
	Improve efficiency of irrigation	x		Reduce water use and return flows to natural systems
	Introduce multi-use water management	x		Minimize changes to flow regimes
Water	Use groundwater to irrigate	x		Reduce pressure on surface water (this may affect surface water resources if highly connected)
Forestry/ Agroforestry	Restore degraded forests,revert cropland to forest	x	x	Increase vegetation cover (better erosion control) and carbon storage, increase biodiversity
	Practice plantation forestry	x	x	Increase carbon storage and improve erosion control
	Integrate perennial crops into cropping systems	x	x	Increase carbon storage and improve erosion control
Livestock/ pastures	Introduce intensive forage-based livestock production	x	x	Reduce grazing pressure, reduce methane emissions, increase carbon storage in pastures
	Improve pastures	x	x	Reduce grazing pressure, reduce methane emissions, increase carbon storage in pastures
Fisheries/ aquaculture	Improve governance and policies of fisheries to protect small-scale fisheries and fishers	x		Improve sustainability of, and provide more equitable access to, fisheries resources
	Integrate fish farming into irrigated agriculture	x		Improve water productivity
	Improve aquaculture in reservoirs	x		Supplement and reduce pressure on native fisheries
	Promote and assist small-scale farmers to comply with Codes of Conduct for goodcaquaculture practices	x		Reduce dependence on trash fish from marine capture, improve quality of effluent water
	Restore mangroves	x	x	Protect coastal land from storm surges, improve habitats and increase biodiversity
	Diversify aquaculture	x	x	Cultivate species lower down the food chain, causing carbon sequestration (as opposed to carbon emissions)

Main messages and recommendations

Southeast Asia's agriculture is changing

Agriculture in the Greater Mekong Subregion (GMS) is shifting from traditional subsistence to modern commercial farming. Countries in the region are following a path of intensification, specialization, increased agrochemical use and mechanization, at varying paces. Agricultural production has increased steadily during the past 20 years, as a result of farmers adopting 'green revolution' technologies. Trends observed in the more developed nations, such as Thailand and China, are likely to emerge in less developed countries in the future.

Population growth, social change and global trade will drive more changes

In the next 20 to 30 years, agriculture will be shaped by a complex mixture of social, economic and environmental pressures, with climate being just one of many factors contributing to change. Food production trends will primarily be influenced by: increased demand prompted by rising populations and dietary changes favoring meat and vegetables; urbanization, offering farmers opportunities to diversify but also putting pressure on water supplies; unpredictable global trends such as fluctuations in oil and food prices, plus the recent global economic crisis; and global investment and trade, particularly China's increasing imports and investment in plantations. Fisheries will also be affected by changes in river flows due to hydropower and irrigation developments.

Climate change impacts are uncertain

Scientists predict that climate change will affect the GMS only moderately in the period to 2050. The changes forecast include rising temperatures and some seasonal shifts in rainfall, with wetter wet seasons and longer, drier dry seasons. Beyond 2050 the rise in temperature will speed up and sea-level rise will accelerate to reach at least one meter (m) above current levels, posing a great threat to farmland in the coastal and delta regions. Climate forecasts are highly uncertain, so governments must take action to build resilient communities that can cope with unforeseen circumstances. People's capacity to adapt to change is closely linked to wealth, diversification of income sources, education and access to infrastructure and technology. Promoting broad-based agricultural development to lift deprived rural communities out of poverty is probably the most effective adaptation strategy available.

Using water efficiently is the key to future food security

Much of the agricultural land in the GMS is prone to floods, droughts or both. Agriculture, urban centers and industry will increasingly compete for water needed to maintain aquatic ecosystems, while climate change may increase the uncertainty of water availability. Around 75% of crops are rain-fed. In many areas, irrigation is not technically or economically feasible, so improving water management is essential. Using conservation farming techniques, plus harvesting and storing run-off on farms, can achieve this. Public irrigation schemes often perform well below their potential due to inappropriate design, operation and maintenance, and improving their performance and flexibility must be a priority. A comprehensive assessment of groundwater potential and use in the region is urgently needed.

Natural ecosystems must be restored and protected

Natural ecosystems underpin production within agricultural, aquacultural and wild-catch fishing industries, and provide a range of other ecosystem services such as flood control, mediation of water quality and biodiversity. Many poor communities rely on fisheries, wetlands and forests for significant proportions of their food and livelihoods. Meeting additional food demands will not be possible without restoring and safeguarding natural ecosystem functions.

To provide sufficient food, governments must 'rethink' agriculture

Given that recent increases in food production in the GMS have come at great cost to the environment and without considerably reducing rural poverty, agriculture now needs an overhaul. To meet future food needs, agriculture must be transformed to deliver food security, ecosystem services (such as clean water, flood protection and carbon sequestration), economic growth, and resilient rural communities. Achieving these goals will demand innovative farming methods and technologies, more efficient use of water, action to protect and restore ecosystem services, plus greater opportunities for the poor.

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Drivers of change in livelihood sectors in the Mekong

Development trends are transforming the Lower Mekong Basin (LMB) ecology and economies at a pace and scale so significant that it becomes difficult to discern the impacts of climate change on livelihoods against the background noise of other changes. Key development influences were identified and assessed for each target livelihood sector.

Agriculture

Understanding the complexity of the agriculture sector and its many drivers helps to design integrated adaptation strategies. Population growth, change in food diet, hydropower

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This article was drawn from a previously published material entitled *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin*: Summary Report (February 2014)". See sourcebox at the end of this article for a complete reference to the original article.

development, agrarian changes, and trends in labor are considered local drivers. The sector is also influenced by direct foreign investment and international market demand for some commodities such as bio-fuel, rubber, and animal feed.

Food demand in the region will continue to rise as populations grow and diets change – higher consumption of fruits, sugar,and oils, for example, will induce changes in the agricultural sector.

National agriculture policies can have far-reaching impacts on the sector, such as those supporting and promoting a specific commodity. In the past decade, Northeast Thailand has been fundamentally modified by support for rubber plantations and development of the rubber industry. Thailand is now the number one rubber producer in the world.

The urbanization process has a major effect on rural development bringing centralization of markets, services, and seasonal and permanent migration of agriculture labor to cities. Urbanization also leads to conflict for landuse as agricultural areas are swallowed up by expanding settlements, industrial zones, and infrastructure.

The LMB is one of the most active regions in the world for hydropower development. The development of extensive networks and cascades of hydropower reservoirs will have far reaching impacts on agriculture in the region. Already, competition for water in the dry season between farmers and electricity producers is a significant concern.

Livestock

Alongside expected climate changes, the basin is undergoing significant socio-economic and physical changes affecting livestock production, consumption, and livelihoods. Increasing household incomes have led to greater domestic demand for livestock-derived products. Globalization, and corresponding growing links to global markets, is promoting competition and subsequent pressure for domestic production.

The high human and livestock populations, number of livestock-raising households, and the nature of production in the basin contribute to emerging infectious disease risks, notably zoonoses. Outbreaks and endemic diseases are major production and public health concerns.

Mechanization and the introduction of higher-productivity genotypes has had varied levels of success impacting yields, costs of production, and disease risks. Increasing concern over and investment in food safety and quality assurance is driving regulatory changes. Agricultural policy and policymaking processes vary widely at sub-national, national, and regional levels but environmental concerns are gaining more weight. At the same time, transparency and associated issues of good governance remain a challenge.

Capture fisheries

Development trends threatening the future of Mekong capture fisheries may completely overshadow the effects of climate change. The productivity of the fishery is inextricably bound up with the seasonal pulse of dry and wet seasons and the connectivity of the rivers, streams, and floodplains. Developments that affect these characteristics will reduce productivity and biodiversity of the fishery, with indirect yet significant effects to the millions of people who depend on the fishery for their livelihoods.

The greatest threats to capture fisheries is the alteration of river morphology and hydrology caused by hydropower projects, the excavation of channels to aid navigation, and the extraction of ground and surface waters for irrigation. Physical barriers constraining the migration of fish species will result in sudden failures of components of the fishery. Plans for cascades of dams, as proposed for the Nam Ngum tributary to the Mekong River, for example, could be catastrophic for this tributary's fishery diversity and productivity. Similarly, the plans for 12 hydropower dams on the mainstream Mekong River would "fundamentally undermine the abundance, productivity, and diversity of the Mekong fish resources" (ICEM 2010).

Other threats include fragmentation of the river and floodplain fisheries (with resultant loss of connectivity); habitat destruction or change; overfishing and aggressive, unsustainable fishing methods, such as explosives; exotic fish populations; water pollution; changes in water flows and levels through dam releases; and climate change mitigation for other sectors (such as large-scale irrigation projects).

There is a tendency to blame unplanned and unwanted events in the region's capture fisheries on climate change, even when other causes seem more likely. Climate change is becoming a scapegoat for shortcomings in more conventional fisheries management. Consequently, climate change presents an opportunity to use vulnerability assessments and adaptation planning as a force for concerted and integrated management of LMB fisheries in ways which address all threats in an integrated way.

Aquaculture

Although aquaculture is seen as a way to offset declining capture fisheries, a number of development trends are adding pressure on the region's aquaculture systems.

Pollution and increasing demand for water during the dry season, for example, has the potential to constrain aquaculture development, particularly in the Mekong Delta. At the same time, it is expected that the increase in dams will result in increased dry season water flows, which would be advantageous for aquaculture.

The use of pesticides and drugs in the more intensive systems are of concern to the region's aquaculture. Their use may be affected by certain diseases becoming more virulent as a result of changed conditions, such as increased temperatures.

Natural systems

In the shorter term, existing threats to the basin's natural systems are more important than the threats from climate change—although addressing existing threats will increase long-term resilience. Habitat loss due to poor protection measures, deforestation, and changes in landuse (e.g. more extensive and more intensive agriculture, plantations, and aquaculture) is very significant. Where the habitats are still more or less intact, over-harvesting and destructive, non-sustainable, and illegal collection are the most important stressors reducing the populations of many NTFPs and overall ecosystem health.

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Overview of livelihood sectors in the Lower Mekong Basin (LMB)

The LMB is a region of rich diversity—of landscapes, biodiversity, and ethnic and cultural diversity. It lies in the Indo-Burma Biodiversity Hotspot, and includes 12 of the World Wildlife Fund for Nature's (WWF) Global 200 Ecoregions: critical landscapes of international biological importance. The region is one of the eight main Vavilov Centers where the wild relatives of most of the world's domesticated plants originated.

The diversity and productivity of the Mekong region is driven by a unique combination of hydroclimatic features that define the timing and variability of water runoff, transport, and discharge through the watershed. The Mekong River is central to the hydrology of the LMB. It is associated with the largest wetland complex in the region. At one time, wetland ecosystems covered much of the basin. Now, about 42% of the LMB is wetland (seasonal and permanent) but only 55,498 km^2 or 22% of that area constitutes natural wetlands. The rest is man-made or converted wetlands mostly associated with agriculture, especially for rainfed and irrigated rice, which is the staple food of the region (ICEM 2012).

The LMB is dominated by agricultural land uses. More than 100,000 km^2 of the basin's total cultivated land is used to produce rice. Already, Vietnam and Thailand use their arable land

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within the basin to its full extent for producing paddy rice and other crops. Commercialization of agriculture has led to the expansion of cash crops, including several tree crops such as rubber, coffee, cashew, fruits, and fast-growing species for pulp and paper. In many areas, commercial plantations have replaced subsistence food crops often involving forest clearing. Other cash crops including cassava, soybean, and sugarcane have expanded rapidly through improved yields and increased area under production.

The Mekong region's forested landscape has been transformed for agriculture and other developments. In the last 35 years, close to one-third of forests have been lost and at current rates little more than 10-20% of original cover will remain by 2030. Large connected areas of "core" forest—defined as areas of at least 3.2 km² of uninterrupted forest—have declined from over 70% in 1973 to about 20% in 2009 with negative implications for the species they sustain (WWF 2013). Deforestation and linked agricultural expansion are the main causes of land degradation in the region affecting between 10 and 40% of land in each country (UNEP and TEI 2007).

During the past two decades, change in farming and natural systems has accelerated due to a wide range of infrastructure developments in particular relating to roads, power facilities and irrigation. For example, GIS analysis by the Mekong River Commission suggests that there are 15,000 to 30,000 dams or full stream impediments to natural flow throughout the basin. Hydropower dams exist or are planned for all of the region's main rivers. As of 2008, some US $10 billion was invested in Greater Mekong Subregion (GMS) transport projects, of which 90% was devoted to roads (ADB 2008). The GMS countries are Cambodia, the People's Republic of China (specifically Yunnan Province and Guangxi Zhuang Autonomous Region), Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam. Transport developments have contributed significantly to poverty reduction in the region, providing access to markets and opening more land for habitation and use.

Economic expansion and demographic shifts are transforming the economies and environment of the region at a pace and scale never before experienced. This trend brings expanding employment opportunities but also carries risks, for example, in terms of increased exposure to price shocks, natural resources degradation, and growing inequities.

The basin supports around 65 million people, some 80% dependent on agriculture and natural resources for their subsistence and livelihoods. All countries of the region have groups and families that remain chronically poor, or are vulnerable to falling into poverty and food insecurity. They are acutely sensitive to adverse weather events such as floods and droughts, as well as to degradation of the natural environment.

An important crosscutting issue is the differentiated impacts of climate change on women, children, and vulnerable groups. Rural communities and households in the basin are not homogenous entities. Disparities exist in terms of assets, access to services and resources, and income opportunities. These considerations are a central focus of rural poverty assessments, yet they require even greater prominence in climate change assessments because existing social disparities are exacerbated as a result of climate shocks. Vulnerable and disempowered groups in the LMB are more affected by negative climate change impacts and have less capacity to adapt to those impacts.

Agriculture

Agriculture is a dynamic sector in the LMB. The production of the major crops has doubled in the last 20 years. The increase in production reflects an intensification of production with higher yields. New areas for cultivation are opening in Lao PDR, the Vietnamese Central Highlands, and Cambodia while the arable land in Northeast Thailand is now decreasing.

Growing conditions are diverse, from the mountainous areas of Lao PDR and the Central Highlands in Vietnam to the lowland plain in the Mekong Delta. Farming systems range from traditional shifting agriculture dominated by upland rice through industrial plantation, including smallholder intensive rice farmers. Rainfed agriculture dominates with rainfed rice the main crop, representing 75% of agricultural area. Around 50% of the rice is produced in the Vietnamese Mekong Delta, followed by Northeast Thailand (around 30% in 2003). Vietnam and Thailand are among the five main rice exporters in the world. Other commercial crops such as maize, soya, or cassava are of growing importance and mostly rainfed.

Subsistence-based systems are inherently integrated with natural systems. These systems tend to be more diverse and complex and a failure in one component can be substituted by another. Consider, for example, the different circumstances of two production systems: one intensively farmed pigs and the other subsistence use of wild pigs. The risks of major productivity losses or cost increases are great in the intensive pig farm if, for example, (i) the price of commercial pig fodder changes, (ii) there is a rapid outbreak of disease, or (iii) there is a heat wave that farm facilities are not designed to accommodate. The subsistence-based system is more resilient because: (i) it is not dependent on fodder, (ii) wild pigs are more resistant to disease outbreaks, and (iii) wild pigs are able to move to cooler habitat in heat wave conditions. Similar comparisons can be made for subsistence capture fisheries and aquaculture or harvesting of non-timber forest products (NTFPs) compared to industrial crops.

Similar patterns can be highlighted across countries with the spread of commercial crops and the emergence of commercial agriculture. Maize is found across all countries, while cassava is already farmed in Thailand and the Vietnamese Central Highlands and is now starting in Lao PDR and Cambodia. Sugarcane is mostly found in Northeast Thailand, with this region accounting for more than 70% of the LMB planted area. The expansions of commercial crops and industrial plantations of rubber, coffee, and eucalyptus are driven by market demand and foreign investment. In the future, demand for bio-fuel (soya, maize, and sugarcane), animal feed (cassava), and starch (cassava) is likely to rise and the demand for rubber and sugar will continue to be strong, also driven by local conditions. In the Vietnamese Central Highlands, for example, the degradation of soil and ground water resources and the lack of rural labor have contributed to a shift from coffee to rubber plantations.

Over the long term, the LMB's agricultural transition from subsistence to commercial and industrial systems can have positive implications for the alleviation of poverty and the provision of food security. However, in the short to medium term, the commercialization of agriculture poses significant threats to the security of the rural poor due to linked natural system degradation, the lack of alternative livelihoods, low labor mobility, loss of land tenure, and higher market prices for food.

Losses in agricultural production due to climate change and other factors will have varied effects depending on the roles that men and women take in production. For example, if women hold primary responsibility for livestock production, losses in that area may affect their income generation. Women are often involved in labor-intensive tasks such as planting and tending crops, so their workload is likely to increase. Also, there is discrepancy along gender lines concerning access to the information required in a changing climate: it is often only men who participate in agricultural extension programs, for example.

A critical issue is ecological sustainability. The shift to commercial agriculture has meant more intensive cultivation of land, clearance of forestlands, increased application of fertilizers and pesticides, and large irrigation diversions. Natural resources are the foundation of rural welfare. The degradation of water supplies, soil erosion, and loss of access to NTFPs all have negative welfare impacts.

Livestock

Livestock production systems in the basin range from traditional smallholder practices to large, highly productive commercial enterprises. Traditional systems are small- scale, using low-intensity, low-input, and low-output approaches. They typically raise stock of local genetics and have limited market orientation. They contribute well over 90% of total numbers of producers in the LMB and over 50% of total production. These systems dominate the higher-elevation forested and more sloping ecozones and typically are associated with low-income, vulnerable households. Women, the elderly, and children are often responsible for household livestock, providing them with an important source of cash income and increased social standing.

In Gia Lai, for example, women take the lead role in raising pigs because this activity normally occurs around the home. Climate changes that result in lower pig productivity and higher mortality may reduce the income earning potential of women. Pigs are also an important form of savings and an asset intimes of emergency. Loss of these assets may reduce the capacity of women to provide food for their family in times of scarcity. Small-and medium-scale commercial operations are most vulnerable and have limited capacity to adapt.

Fisheries

Capture fisheries and aquaculture are vitally important for food and for the livelihoods. Mekong communities have the highest per capita consumption of fish in the world — up to 50 kg/head/year in some parts of the basin.

Capture fisheries

The basin's capture fisheries are crucial for food security. The LMB's freshwater fishery is the world's largest, producing some 2.1 million tonnes per year (close to 22% of the world's freshwater fish yield). The region also has a substantial coastal fishery producing 0.5 million tonnes per year. This catch of fish is supplemented by about 0.5 million tonnes per year of other aquatic animals (for example, freshwater shrimps, snails, crabs, and frogs).

With 781 known species, it is home to the second highest fish biodiversity in the world after the Amazon River. Virtually all fish species have a commercial value. The small-scale mud carp, for example, is of huge importance for fish paste production in several Mekong countries. The biodiversity and productivity of the fishery is linked inextricably to the annual flood pulse and the diverse range of natural habitats it maintains — as well as some artificial habitats such as rice fields and reservoirs. Although the fishery is very productive, there are serious declines in the stocks of certain species, including some of the giant fish species. In addition, the average size of some species is reducing, suggesting stocks are being over-fished and changes to habitats are affecting life cycles.

Despite the seasonal abundance of fish, many households remain desperately poor—and with few other livelihood opportunities, a decline in the Mekong capture fishery would be catastrophic for them.

Upland fishes

The fishes of the small streams in upland areas of the Mekong Basin are often overlooked by fisheries scientists, as their contribution to total fisheries productivity is modest.
However, as other hunting options decrease, an increasing number of upland households now rely on fish products from small water bodies and streams in the uplands. These fish, which inhabit the cool clear waters of upland forests, look particularly vulnerable to a wide range of pressures, including climate change.

Aquaculture

Over the past 30 years, the Mekong's aquaculture sector has boomed, providing livelihoods to hundreds of thousands of households. The latest production estimates of around 1.9 million tonnes are now similar to the production levels from the capture fisheries and looks set to surpass capture fisheries over the next few years. Much of this production (1.6 m tonnes) is from intensive catfish culture (particularly *Pangasius* spp) and shrimp farms and is destined for export. Traditionally, many aquaculture systems have been dependent on the capture fisheries for wild-caught juveniles for culture and low-value fish for feed. However the development of hatcheries and the increased availability of commercial fish feeds throughout the LMB have reduced this dependence on wild resources.

Semi-intensive and extensive aquaculture systems often include a significant proportion of wild fish in the harvests. A wide range of indigenous species are cultured in the LMB. A number of exotic species are also cultured, often in polycultures with indigenous fish. In the Thailand part of the LMB, tilapia is the most commonly cultured fish (41%) followed by clarias catfish, (26%), barbs (11%), snakeskin gourami (7%), and giant freshwater prawns (6%). In the Delta, aquaculture production is dominated by pangasids (1.6 million tonnes/year) followed by tiger shrimp (*Penaeus monodon*), although production there is now facing environmental and economic constraints.

Current trends in aquaculture include a reduction in use of low value fish for fish feed, an increase in the use of hatchery-reared juveniles, and the culture of 'new' fish species/strains such as 'tub tim' fish (*Oreochromis* spp). As LMB countries become wealthier, the demand for diverse and inexpensive fresh fish is increasing. It is unlikely that the capture fisheries, no matter how well-managed, would be able to keep pace with this demand. The disappearance of some fish species from the capture fishery (e.g. *Oxyeleotris marmorata*) and the growing market acceptance of exotic fish such as tilapia are creating opportunities for aquaculture. The sector therefore looks set to continue to grow, generating wealth and creating new livelihood opportunities for rural people.

Much of this aquaculture expansion has resulted in new areas being utilized for aquaculture. This is certainly true of the coastal region where large areas of mangrove and/or rice fields have been converted to shrimp farms. Large freshwater wetland areas considered suitable for the expansion of inland aquaculture also exist. However, environmental constraints are starting to affect aquaculture production and diseases and water quality issues are increasingly affecting production in intensive culture systems. Any increased costs of farmed fish resulting from climate change adaptation measures could have a serious indirect effect on poorer people's diet where no other obvious animal protein alternatives exist.

Natural systems

Natural ecosystems within and outside protected areas are under pressure throughout the Lower Mekong region. Healthy natural systems are a foundation for the development and well-being of livelihood systems and are essential in building resilience in communities and across economic sectors. They are critical to food security. Even households that have moved beyond a marginal existence and possess productive assets, such as irrigation infrastructure and farm machinery, have much to lose from reduced access to healthy natural systems and resources.

NTFPs make a significant contribution to national and local economies in the region and can make up over 30% of the income of individual farming families. Crop wild relatives (CWRs), often forgotten by all except crop researchers, are important as a source of genetic material for the improvement of existing crops, including the development of resistance to disease and extremes of temperature and drought. Protected areas now represent the last vestiges of the original plant and animal assemblages of the region and, for many NTFPs and CWRs, the only areas where they grow in the wild.

Protected areas

The four countries of the LMB—Cambodia, Lao PDR, Thailand, and Vietnam—have established one of the largest protected area systems in the world. Those systems include more than 116 protected areas in the LMB covering 16% of the basin's land area. In Cambodia, Lao PDR, and Thailand, the protected area systems cover well over 20% of national land area.

Most of the significant remaining forest areas and upper watershed areas of the LMB are contained within these protected areas. All the protected areas and linked natural areas of forest and wetlands are of increasing importance as an essential part of healthy productive farming ecosystems—increasing as populations grow and as access to arable land diminishes.

Around 90% of the basin's protected areas have communities living within them—and most are experiencing growing populations. More than 25% of the region's protected areas is used for agriculture, 30% for grazing, 30% for fisheries, and 90% for hunting, gathering, and extraction. In addition, protected areas in all countries except Thailand are open for major infrastructure development such as hydropower schemes, roads, mining, plantations, and tourism facilities.

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Ariel Lucerna 2015

Towards an enabling environment for advancing disaster risk reduction and climate change adaptation

Introduction

An enabling environment plays a critical role in the advancement of DRR and CCA in the Asia-Pacific region. Its importance in achieving a more integrated implementation of CCA and DDR is illustrated in Figure 1, which adopts a risk-based approach to adaptation in order to harmonize DRR and CCA as much as is practicable and desirable. This is regardless of whether the initiatives are at community of national level. But at national level, governments in particular have the important responsibility of ensuring a strong enabling environment, as well as benefiting from that enabling environment when undertaking CCA and DDR measures themselves.

As indicated below, a critical aspect of the enabling environment and a foundation for knowledgeable decision making is to have access to relevant hazard information. Thus national meteorological and hydrological services have an important role to play ensuring access to reliable and long-term natural resource data.

This article was drawn from previously published material entitled *At the Crossroads–Climate Change Adaptation and Disaster Risk Reduction in Asia and the Pacific: A review of the Region's Institutional and Policy Landscape* by UNISDR Asia and Pacific Secretariat. Refer to the source box towards the end of this article for a complete reference to the original article.

The responsibility of government to ensure a strong enabling environment is of critical importance to communities since this is where most CCA and DRR activities are focused. Communities will see more value in pursuing an integrated approach if it is already reflected in national and sectoral development policies and plans. Communities will benefit from a more coordinated and harmonized approach that is consistent across all government agencies. Governments can help ensure that communities are equipped with the requisite knowledge and skills required to support decision making and implementation, and have access to proven technologies which are consistent with their needs and values.

Few et al. (2006) have used examples from Mexico, Kenya and Vietnam to provide insights into how a more integrated approach to DRM and CCA can contribute to sustainable poverty reduction and other development outcomes. The main emphasis in the analysis was placed on institutional capacity as well as on constraints and opportunities within the policy process.

Figure 2 summarizes their findings in terms of commonalities in enabling factors in the implementation of integrated DRM, CCA and poverty reduction. The findings highlight the importance of incorporating livelihood resilience, information packaging, communication, coordination, financing and supporting an enabling environment.

Few et al. (2006) also show that a key step in demonstrating through operational work that DRR addressing climate change is possible and beneficial is to find relevant entry points that can showcase how action is feasible and worthwhile, building on current capacity. These entry points can also be used to show how benefits can be linked to current vulnerabilities and to high-level policy goals such as poverty reduction strategy targets and the MDGs.

Environmental and health impact assessments are effective entry points for intersectoral cooperation on DRR and CCA. As they are typically high policy priorities, assessments and activities designed to enhance food, water and human security also provide useful entry points as all are sensitive to climate change and are usually important dimensions of natural disasters. Holistic but practical and locally-focused approaches, such as an ecosystem-based planning, also provide excellent opportunities to promote the integration of DRR and CCA.

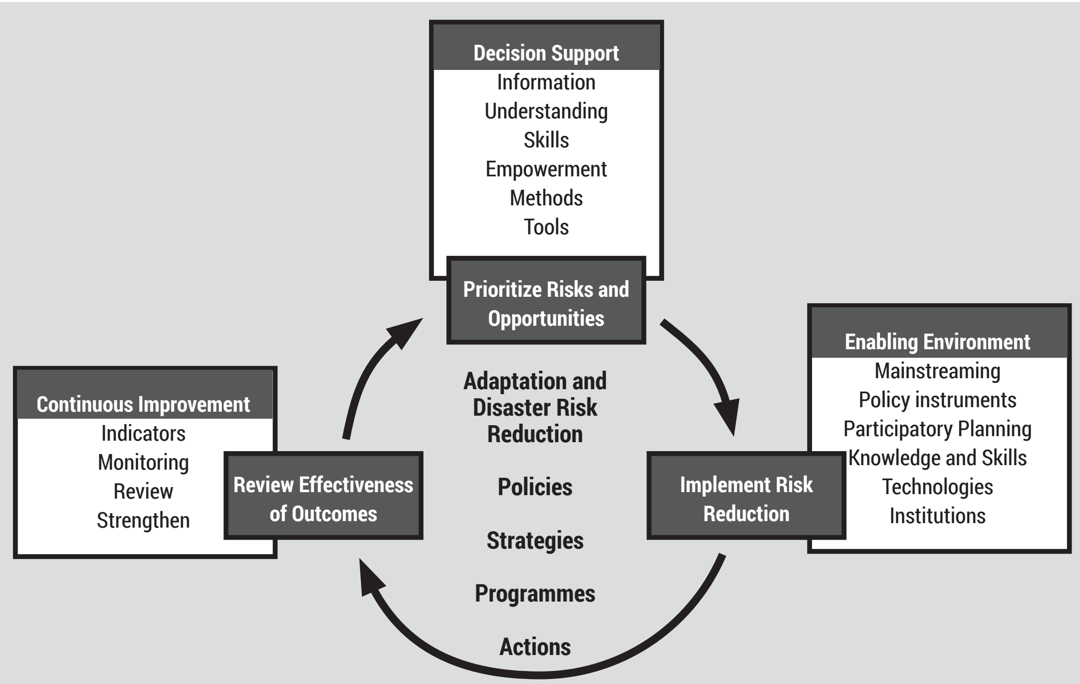

Figure 1. Policy framework for CCA and DRR, made possible through a risk-based approach to adaptation. (Source: Adapted from Hay 2010)

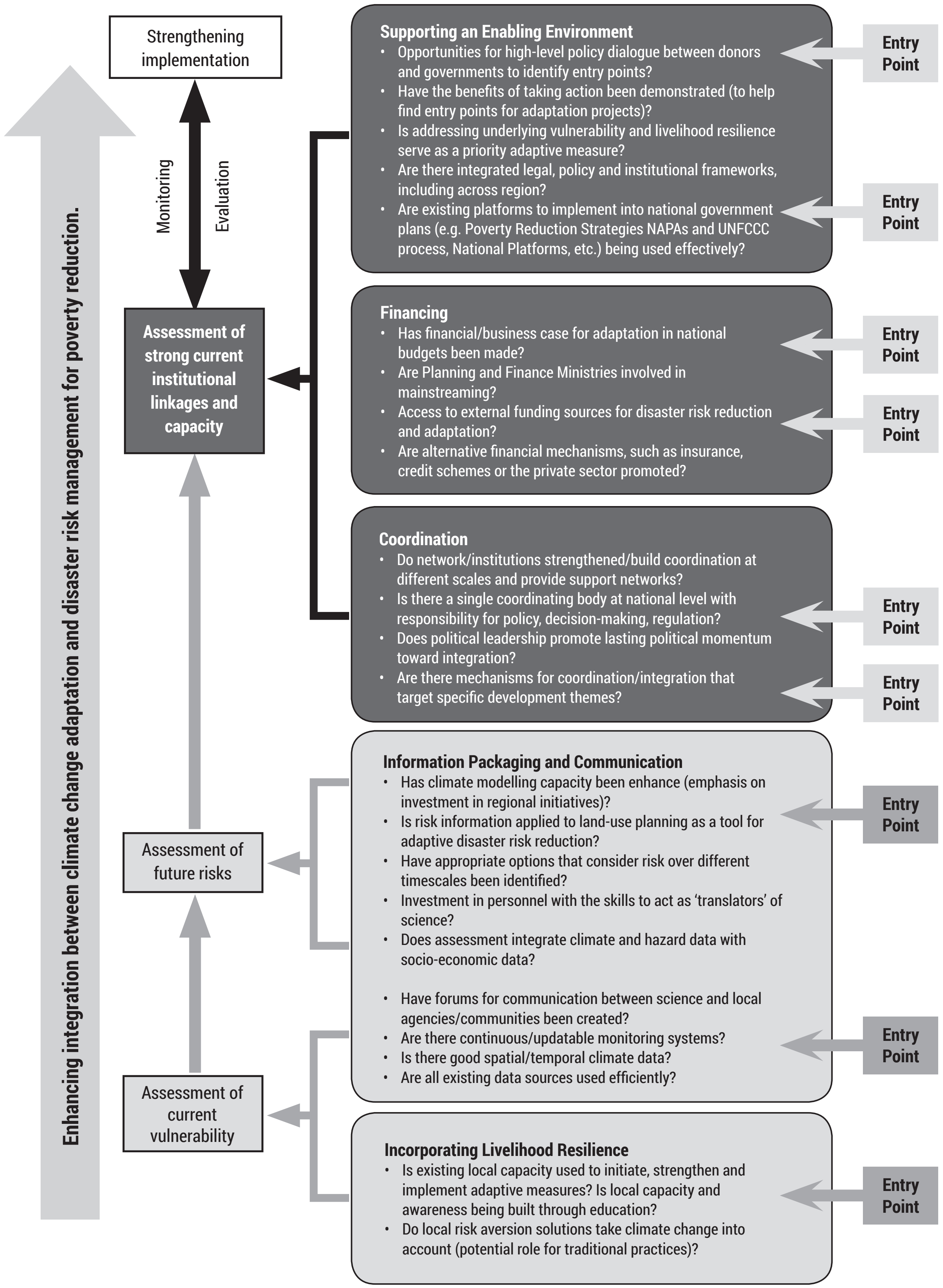

Figure 2. Commonalities in enabling factors in the integration of DRM, CCA and poverty reduction, and relevant entry points. (Source: Adapted from Few et al, 2006)

Other relevant entry points include:

- Engineering design studies for infrastructure;
- Visioning activities, at community to national level;
- Multi-hazard risk assessments such as development of integrated coastal management plans;
- Local government strategic planning;
- Midterm and final reviews of projects;
- Preparing work programmes of high-level national coordinating institutions;
- Preparation of integrated national policies, legislation or progressive development strategies;
- Development of capacity building strategies, including both top-down and bottom up strategies such as those designed to strengthen community capacity for promoting integration of DRR-CCA into development at the local level; and
- Sourcing funding (internal or external) for projects designed to reduce vulnerabilities and enhance resilience.

The World Bank's Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects provide lessons learned, best practices, recommendations, and useful resources for integrating climate risk management and adaptation to climate change in development projects, with a focus on the agriculture and natural resources management sectors. They are organized around a typical project cycle, starting from project identification, followed by project preparation, implementation, monitoring and evaluation. Each note focuses on specific technical, institutional, economic, or social aspects of adaptation.

CARE has also developed the Climate Vulnerability and Capacity Analysis (CVCA) methodology, based on a framework of "enabling factors" for CBA (Dazé et al., 2009). CARE's approach to CCA is grounded in the knowledge that people must be empowered to transform and secure their rights and livelihoods. It also recognizes the critical role that local and national institutions, as well as public policies, play in shaping people's adaptive capacity. By combining local knowledge with scientific data, the process builds people's understanding about climate risks and adaptation strategies. It provides a framework for dialogue within communities, as well as between communities and other stakeholders. The results provide a solid foundation for the identification of practical strategies to facilitate community-based adaptation to climate change.

It appears that pinning down the required regional enabling environment for the practical integration of disaster risk reduction and climate change adaptation in Asia and the Pacific is very challenging. Two enabling factors that could foster DRR and CCA integration at the regional level. These are (a) the political commitment and awareness of regional intergovernmental organizations and (b) the regional policy and institutional mechanisms related to DRR and CCA.

Source: At the Crossroads - Climate Change Adaptation and Disaster Risk Reduction in Asia and the Pacific: A review of the Region's Institutional and Policy Landscape

Published by: UNISDR Asia and Pacific secretariat

July 2011

Reference

Few, R., Osbahr, H., Bouwer, L.M., Viner, D. and Sperling, F. (2006). Linking Climate Change Adaptation and Disaster Risk Management for Sustainable Poverty Reduction. Synthesis Report.

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Implication of climate change for rural development programs

Climate change does not mean throwing out or reinventing everything that has been learned

As a starting point, it is important to recognize that responding to climate change does not mean throwing out or reinventing everything that has been learned about agriculture and rural development. Instead, it requires a renewed effort to tackle wider and well-known challenges. Many of IFAD's programmes are implicitly or explicitly designed to increase the resilience of smallholders and poor communities to shocks, which are often weather-related. A coherent response to climate change requires continued emphasis on, for example, country-led

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This article was drawn from previously published material entitled *Climate-smart smallholder agriculture: What's different?* by Elwyn Grainger-Jones and Per Rydén. Refer to the source box towards the end of this article for a complete reference to the original article.

development, community-based natural resource management, gender awareness, targeting of poor rural people, dealing with land tenure issues, improving access to financial services and markets, increasing sustainable productivity, and institutional and human capacity-building. It remains essential to promote good governance and to both empower farmers and recognize the relevance of their traditional and indigenous knowledge in addressing issues such as climate variability, and the differences between women's and men's knowledge and roles in responding to climate change. As set out in Toulmin (2011):

The root of smallholder vulnerability lies in the marginalisation of farmers, pastoralists and other rural groups in power and decision-making. This is a fundamental problem for smallholders everywhere, and a consequence of their large numbers, weak and costly organisation and consequent very limited political power.

So what's really different?

But beyond regular development best practice, what really is different about climate-smart smallholder agriculture? This paper sets out three major changes, responding to climate change, in how government and donor support to rural development—and smallholder agriculture in particular—is practised. In summary, project designs need to reflect a different context, in which vulnerability assessments, opportunities for payment for environmental services (such as emissions reductions) and greater use of climate scenario modelling are likely to alter the balance of activities and the way these are implemented. In many cases, this will lead to more-rapid scaling up of successful approaches that have already been piloted in various ecosystems, such as agroforestry, sustainable land management and conservation watershed management, but in a way that is fully cognisant of potential climate impact scenarios.

Project and policy preparation need to be based on better risk assessment

Project and policy preparation need to be based on deeper risk assessment, with a better understanding of interconnections between smallholder farming and wider landscapes. Climate change is now changing the context quickly enough for us to have to think about it in project design. It is a 'threat multiplier' for smallholders, increasing existing livelihood threats and vulnerabilities, rather than an isolated specific risk:

- **Climate change will magnify traditional risks.** Historical averages can no longer be relied on since climate change is increasing variability, the range of extremes and the scale of volatility and risk. For example, historical drought or flooding frequency is no longer a straightforward guide to the future.
- **There will be new sources of risk beyond the traditional ones,** such as sea-level rise and glacier-melt impact on water supply. Smallholder farms will need to increase their general resilience to withstand currently unidentified direct and indirect shocks. New opportunities for greenhouse gas emissions reduction rewards and carbon financing schemes can bring their own risks—for example, if poor people were to remain without access to emissions reduction rewards as a consequence of social exclusion and limitations on land-use rights.
- **The impact of a changing climate on long-term trends needs to be better understood over time.** Although predictive capability will increase with new data and enhanced decision-support tools, climate uncertainty will continue to be a challenge. While impacts are already being felt, they will worsen increasingly in the years to come. Many project investments are expected to have a lifespan of 20 or more years, well within the time frame for further significant climate impacts. This is especially important in agriculture, where most of the main staple crops are already being grown at their temperature threshold. For many regions, despite the fact that science is yielding clearer projections (e.g. drought in North Africa), traditional project appraisal has often discounted such future project risks. Of foremost concern is the need to avoid 'maladaptation'—project design that exacerbates vulnerability—for example, facilitating habitation in a flood plain or low-lying coastal area.

This means recognizing the complexity of people's interaction with landscapes

These risks need to be understood in the context of the complexity of people's interaction within their communities and with landscapes and ecosystems. Embracing such complexity certainly adds to the effort involved in policy and project design, but can lead to better (and often simpler) solutions. The range of tools and approaches available to map risk and vulnerability at the community and landscape level is increasing rapidly. For example, better spatial analysis supported by geographic information systems can identify how investments or management practices in some parts of a landscape or watershed can produce benefits or reduce negative impacts in other parts, to provide 'connectivity' of hydrological systems or wildlife habitat.

Uncertainty regarding climate impacts is no reason for inaction

Uncertainty regarding climate impacts is no reason for inaction. New downscaled climate models provide opportunities to reduce uncertainty in local vulnerability assessments, particularly where there is concurrence among global climate models in some regions (Wilby and Fowler, 2010). Information can be gathered, for example, on day- and night-time temperature increases, water availability, shifts in vegetative cover and soil fertility. Where uncertainty remains, there are many 'no regrets' actions that can have significant development benefits under a range of climate scenarios. A key immediate priority is to help communities build resilience to withstand a range of potential shocks while also adjusting to longer-term climatic trends where these are clearer. Most of the examples presented in this paper are useful in maintaining agricultural production with or without climate change—for example, diversifying household food production, enhancing agricultural extension services, promoting better crop diversity and biodiversity, integrating farming and agroforestry systems, and improving post-harvest management to reduce losses in terms of quantity and nutrient content (UNSCN, 2011).

This deeper appreciation of interconnected risks should drive a major scaling up of successful 'multiple-benefit' approaches for sustainable agricultural intensification. Over the last few decades, a wide range of approaches has been developed that typically maximize the use of natural processes and ecosystems, reduce excessive use of external inorganic inputs, enhance the diversity of production and tailor production intensity to the capacity of the landscape, and use a mix of traditional and new technologies (see Figure 1).

The technical foundations of climate-smart agriculture already exist. There are many examples to choose from. Terracing or bunding prevents soil loss through erosion and water flooding, and thereby loss of soluble nutrients, while allowing water retention. Minimum or zero tillage, coupled with crop rotation and the application of manure, compost or mulching, and the fallow system can improve soil structure and fertility and build up organic matter in the soil and its water-holding capacity. Adding manure to the soil supports a mixed system of livestock/crop production that diversifies risks across different products. This also implies a

Approach:

- Maximum use of natural processes and ecosystems
- Less external inorganic inputs and waste
- Diversity and proportionality of production
- Misture of traditional and new technologies

Primary impact:

- Maintained and enhanced groundcover
- Healthy soil that can retain nutrients and moisture
- Enhanced biodiversity
- Multi-seasonal in situ water storage

Multiple benefits

- Yields
- Profit
- Climate resilience
- Emissions reduction
- Local pollution reduction
- Poverty reduction

Figure 1. Approach, primary impacts and multiple benefits.

system of crop rotation—production of both food crops and fodder crops—which reduces risk at the farm level and often improves family nutrition. Agroforestry is another integrated system that combines trees with agricultural crops and/or livestock. The trees can in themselves be a source of income depending on the species. They can also serve to improve soil quality through nitrogen fixation (if they are legumes) and capture nutrients from deep in the soil (making them available through leaf litter), in addition to creating a more favourable microclimate. Better management of grazing land or pasture can also increase soil carbon content and productivity. Rotational grazing or a combination of stall feeding and grazing, based on fodder crops and limiting the dependence on grazing, can result in increased productivity in the livestock sector, combined with a build-up of carbon stock in the rangelands.

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Source: Climate-smart smallholder agriculture: What's different?
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Making climate-smart agriculture work for the poor

The need to transform agriculture

By 2050 approximately 70% more food will have to be produced to feed growing populations, particularly in developing countries. Agriculture is already causing increased conversion of lands and placing greater pressure on biological diversity and natural resource functions than ever before. As climate change causes temperatures to rise and precipitation patterns to change, more weather extremes will potentially reduce global food production.

Agriculture is rapidly evolving to address these drivers of change, for instance through irrigation, fertilizers and the provision of better germplasm for higher productivity and improved products. In many less developed parts of the world, increased production has occurred through the expansion of agricultural lands rather than through intensificatio. At a global scale, both intensification and extensification are currently having a significant negative effect on the environment; depleting the natural resource base upon which we rely.

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What is climate-smart agriculture?

Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals.

Food and Agriculture Organization of the United Nations

The need to reduce the environmental impacts while increasing productivity requires a significant change in the way agriculture currently operates.

'Climate-smart agriculture' has the potential to increase sustainable productivity, increase the resilience of farming systems to climate impacts and mitigate climate change through greenhouse gas emission reductions and carbon sequestration.

It's all about scale

Climate-smart agriculture can have very different meanings depending upon the scale at which it is being applied. For example, at the local scale, it may provide opportunities for higher production through improved management techniques such as more targeted use of fertilizers. At the national scale it could mean providing a framework that incentivizes sustainable management practices. And at the global scale it could equate to setting rules for the global trade of biofuels. It is not clear how actions at one scale may affect the others.

For smallholder farmers in developing countries, the opportunities for greater food security and increased income together with greater resilience will be more important to adopting climate-smart agriculture than mitigation opportunities. For intensive mechanized agricultural operations, the opportunities to reduce emissions will be of greater interest.

Opportunities for climate-smart agriculture to mitigate climate change, improve resilience to climate impacts and increase food security/livelihoods

Table 1 shows just some of a range of practices that are consistent with climate-smart agriculture in smallholder systems as well as in line with the AU-NEPAD Agriculture Climate Change Adaptation-Mitigation Framework. While most of these are applicable to all regions and climates of the tropics and subtropics, some practices are more appropriate to humid conditions (e.g. rice management), to drylands (e.g. grassland restoration, drip irrigation or to slopes (e.g. terraces, contour planting).

Table 1. Climate-smart practices useful in smallholder agricultural production.

Crop management	Livestock management	Soil and water management	Agroforestry	Integrated food energy systems
• Intercropping with legumes • Crop rotations • New crop varieties (e.g. drought resistant) • Improved storage and processing techniques • Greater crop diversity	• Improved feeding strategies (e.g. cut 'n carry) • Rotational grazing • Fodder crops • Grassland restoration and conservation • Manure treatment • Improved livestock health • Animal husbandry improvements	• Conservation agriculture (e.g. minimum tillage) • Contour planting • Terraces and bunds • Planting plots • Water storage (e.g. water pans) • Alternate wetting and drying (rice) • Dams, plots, ridges • Improved irrigation (e.g. drip)	• Boundary trees and hedgerows • Nitrogen-fixing trees on farms • Multi-purpose trees • Improved fallow with fertilizer shrubs • Woodlots • Fruit orchards	• Biogas • Production of energy plants • Improved stoves

All the practices shown in Table 1 address food security and lead to higher productivity, but their ability to address adaptation and mitigation varies. In most cases food security improvements will also raise the adaptive capacity of farmers, but there can be trade-offs between adaptation and mitigation goals. For example, if not carefully planned, the production of biofuels could lead to competition with crop production and negatively affect adaptation and food security.

Constraints

Many climate-smart agricultural practices can be integrated into a single farming system and will provide multiple benefits that can improve livelihoods and incomes. However, there are practices that cannot be integrated because they impact upon other elements of the farming system. For example: the timing of a practice may lead to labour constraints; high investment or maintenance costs may exceed the capacity of asset poor farmers; and competition for crop residues may restrict the availability of feed for livestock and biogas production. Identifying these constraints is important to developing economically attractive and environmentally sustainable management practices that have adaptation and mitigation benefits.

Constraints

Food insecure farmers find it hard to innovate and invest in better management systems when they are fully occupied finding sufficient food to survive.

Many climate-smart agricultural practices incur establishment and maintenance costs and it can take considerable time before farmers benefit from them.

Access to markets and capital are key constraints for resource-poor farmers, and limit their ability to innovate and raise their income.

What should be done to overcome the challenges to introducing climate-smart agriculture?

Provide an enabling legal and political environment with an overarching national plan, appropriate institutions and effective and transparent governance structures that coordinate between sectoral responsibilities and across national to local institutions.

Improve market accessibility to enhance incomegenerating opportunities provided by agroforestry. This can be done through improving infrastructure or more locally through establishing cooperatives that pool resources to access markets. As shown above, one of the most effective ways to reduce a farmer's vulnerability to climate change is through improving their income. In comparing benefits derived from agroforestry in Kenya, Thorlakson (2011) found that market access played a key role in improving household incomes.

Involve farmers in the project-planning process. Farmers' input should be used to ensure development projects target what is most relevant to local communities and be designed to accomplish agreed goals in the most effective way within the local context.

Improve access to knowledge and training. This has been shown to significantly improve farmers' willingness to plant more trees for multiple purposes. Kiptot et al. (2006) showed that farmer to farmer dissemination provides a potential alternative mechanism for the spread of agricultural technologies and Thorlakson demonstrated that educational farm visits to successful management practices can increase adoption rates.

Introduce more secure tenure. This can have a significant effect on farmers' willingness to invest in their land and improve productivity. Norton-Griffiths (2008) showed that among smallholder farmers in Kenya, net returns on adjudicated land was approximately three times higher than on unadjudicated land where tenure is less secure. Investments in crop diversity, improved livestock and fodder crops, agroforestry and soil conservation were all substantially higher on more securely tenured land.

Overcome the barriers of high opportunity costs to land so that smallholder farmers can improve their management systems. This is a key requirement for successful implementation of climate-smart agriculture in developing countries and to-date it has been given little attention. Many improved management practices provide benefits to farmers only after considerable periods of time. This can be inhibitive to poor households because investing in new practices requires labour and incurs costs that must be borne before the benefits can be reaped. Pairing short-term with longer term practices may overcome some of the timing constraints.

Improve access to farm implements and capital. Payments for carbon sequestration may be an appropriate way of covering the time lag between investing in climate-smart practices and obtaining the environmental and economic benefits. Currently only Plan Vivo provide activity-based ex-ante payments for terrestrial carbon sequestration 23. Other financial instruments, such as microcredits or index insurances, could provide the necessary funds or minimize risk to overcome these investment gaps.

Recommendations

Development and climate finance programs must focus on improving livelihoods and income so that there is incentive for smallholder farmers to invest in climate-smart agriculture.

Combining practices that deliver short-term benefits with those that give longer-term benefits can help reduce opportunity costs and provide greater incentives to invest in better management practices.

National agriculture development plans with appropriate institutions at national to local levels, provision of infrastructure, access to information and training and stakeholder participation and, last but not least, improvement of tenure arrangements are necessary for long-term transformation towards sustainable intensification and management of resources.

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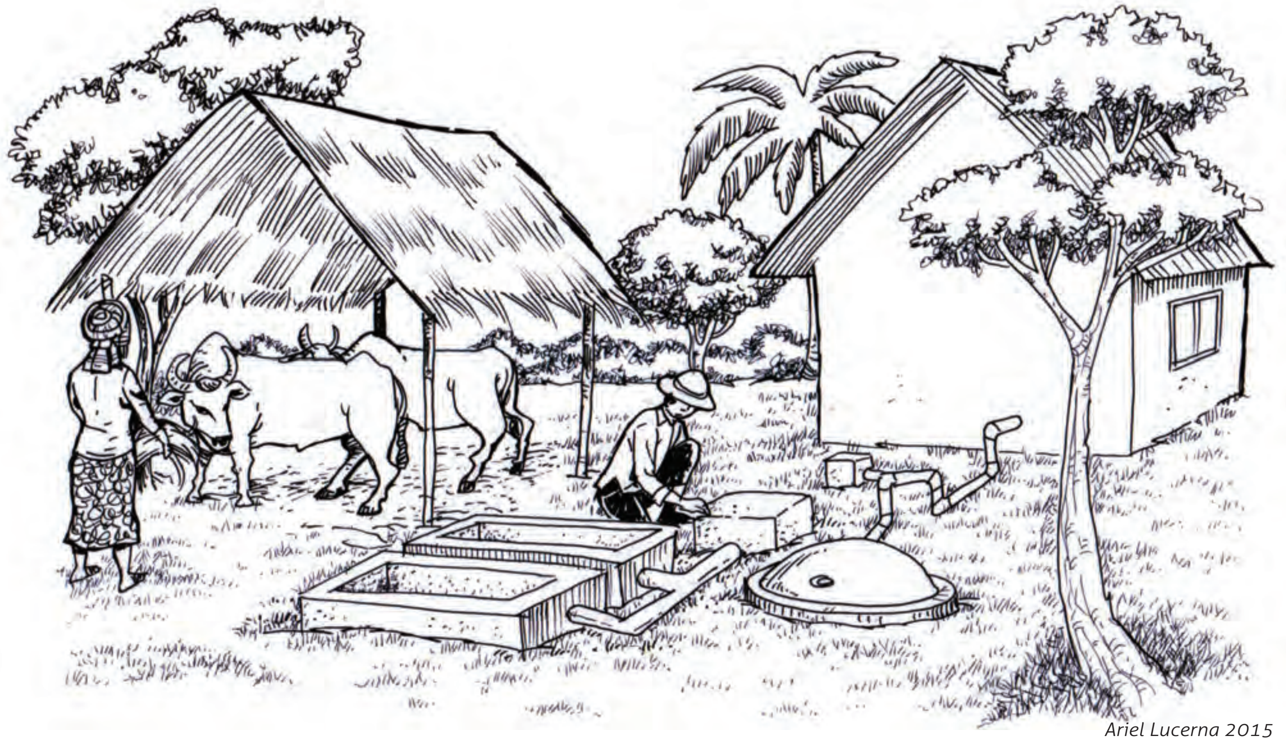

Ariel Lucerna 2015

Climate constraints to the agricultural sector in Cambodia

Many schools of thought in the literature give different insights and perceptions on climate change. The National Oceanic and Atmospheric Administration (NOAA 2008) defines climate change as a long-term shift in weather norms (including its averages). It can be seen for a given place and time of year, from one decade to the next, as a change in normal climate (i.e. expected average values for temperature and precipitation). Climate change can be caused by: 1) natural variability, i.e. it is a normal part of the Earth's natural variability, which is related to interactions among the atmosphere, ocean and land, as well as changes in the amount of solar radiation reaching the earth; and 2) human-induced change, especially the greenhouse gases resulting from natural phenomenon and the burning of fossil fuels which releases gases that trap heat in the atmosphere.

Even a slight increase in temperature across a country or a region will increase the overall temperature of the world for the next centuries. The United Nations Environment Programme is based on the premise that "climate change is the defining challenge of our generation and it is no longer relevant to discuss whether or not our climate is changing, but rather, how fast changes will occur" (UNEP 2009). The National Climatic Data Centre reports that atmospheric concentrations of both natural and man-made gases have been rising over the last few centuries. Due to its increasingly unpredictable and alarming impacts on the environment and

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human beings, climate change is now universally acknowledged as a global issue which requires all countries to work collectively to mitigate the problem under bilateral, regional and international frameworks.

Cambodia has frequently suffered catastrophic damage from natural disasters, notably drought, flood, storm and after-effects such as flash floods (e.g. cyclone Ketsana in 2009), particularly in the many rice producing provinces in the Tonle Sap Lowlands and along the Mekong River. The majority of the rural poor rely on the regularity of the wet and dry seasons, especially for crop farming, which affects all aspects of their lives from income generation, consumption, nutritional status, education and health (RGC 2002b: 42). The agricultural sector is especially hard hit by natural disasters; not only crops, but infrastructure, buildings and equipment are destroyed. Given that the agricultural sector is a key contributor to the national economy, the impact of natural disasters reverberates beyond its confines. The Strategy for Agriculture and Water (SAW 2007: 6) highlights natural disasters as one of nine major factors that pose potential threat to Cambodia's agriculture and water sectors (TWGWA 2007).

General overview of Cambodia's climate

Cambodia is located on the south-western part of the Indochina peninsula, between 10° to 15° north latitude and from 102° to 108° east longitude. It is bordered by Thailand to the west and north, Laos to the north, Vietnam to the east and south, and the Gulf of Thailand to the southwest. Cambodia is a low lying country and rich in water resources. The Mekong River supplies surface water to the eastern part of the country while the Tonle Sap River Basin supplies the central and western parts.

Cambodia has a tropical monsoon climate, dominated by southwest monsoon (mid-May to October) and northeast monsoon (October to April) (Khun 2002). The monsoon climate creates two main seasons: the wet season runs from May to November when the average temperature is 27°C to 35°C; the dry season is from November to February, and the average temperature ranges from 17°C to 27°C. March to May is the hottest time of the year with temperatures of about 29°C to 38°C (Khun 2002). Humidity is 65 to 70 percent in January and February, and 85 to 90 percent during August and September. Annual evaporation is 2000-2200 mm, with the highest in March and April at 200-240 mm per month, and the lowest in September and October at 120-150 mm per month. Monthly average evapotranspiration is about 120 mm in the dry season and 90 mm in the wet season (Chann 2002).

Farmers cultivate rice in both dry and wet seasons. The rice cultivated area has expanded annually over the last two decades. Average rice yield in 2008 was reportedly about 2.2 tonnes per ha in rain-fed or non-irrigated areas and 3.2 to 3.5 tonnes per ha in irrigated areas (MOWRAM 2009). MAFF data record that the average rice yield in 2010 was about 4.2 tonnes per ha in the dry season and 2.76 tonnes per ha in the wet season (MAFF 2011a:19). Most agricultural areas are rain-fed. Farmers still rely on rain-fed agriculture and grow one crop per year. The average annual rainfall is 2000-3000 mm in the Mountainous area, 4000 mm in the Coastal area and 1400-1600 mm in the Plains area (Khun 2002).

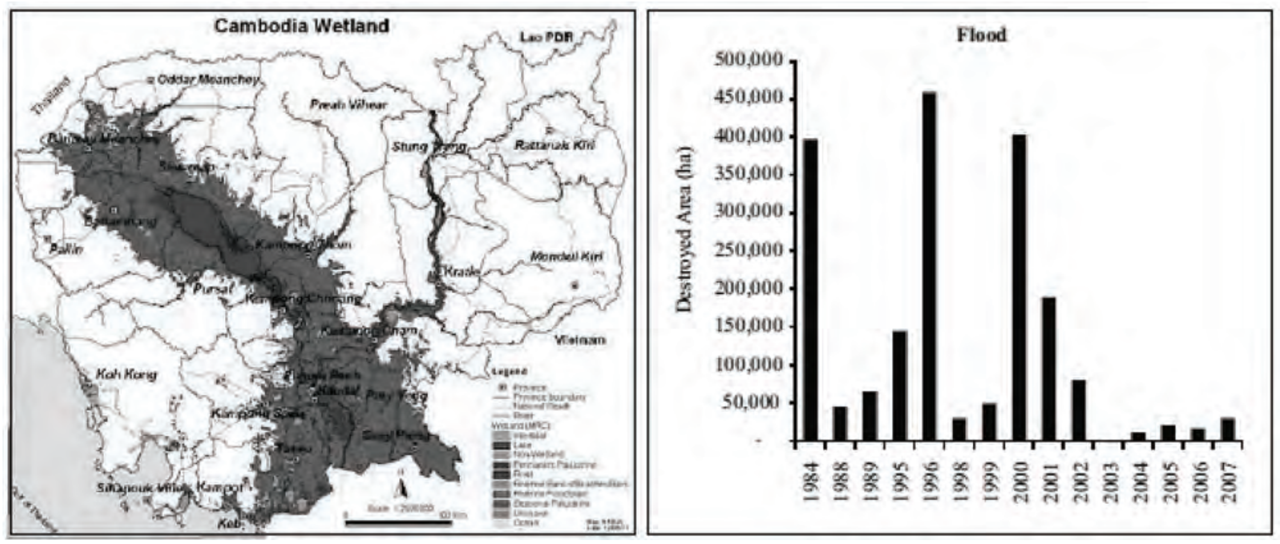
Rice, maize, cassava, soybeans and mung beans are the main crops grown in Cambodia. Given the country's fertile soils, vast arable land and plentiful water resources, there is great potential to increase rice production. Rice is the staple food accounting for 68-70 percent of daily calorie intake (Mak 2004) and is important for national economic development. Government, the private sector and donors have provided new varieties of high-yielding rice seed, fertilisers and extension services to help train farmers in new technologies and methods to increase rice productivity (Hegadorn 2011). Efforts are being made to diversify crop

production and encourage development of agro-industry plantations. Agricultural production offers potential for long-term development and sustainable rural income (MAFF 2011d). Agro-industrial plantations of rubber, cassava, sweet potato, sugarcane and oil-palm have been established in ELC areas in 16 provinces. Based on national agricultural statistics, the agricultural sector's share in GDP by 2010-end (at constant 2000 prices) was about 29 percent (MAFF 2011a). Even though Cambodia encounters less natural disasters per annum than its neighbouring countries, its limited adaptive capacity makes it particularly vulnerable to the impacts of global and regional climate change (Arief and Herminia 2009). Historically, the country has suffered many natural disasters including the drought in 2002 (419 people affected) (Khun 2002), floods along the Mekong River in 2000 (347 deaths) (MOWRAM 2010), storms and the after-effects such as flash floods (e.g. cyclone Ketsana in 2009 which left 43 dead). These disasters caused loss of life, destroyed social infrastructure and severely damaged agricultural production in rural areas (Khun 2002).

Flood

Agricultural areas, especially the Tonle Sap Plain and areas along the Upper and Lower Mekong Rivers are affected by floods for several months every year. The flooding of the Mekong River is a vital part of the natural cycle. Monsoon rains flow down to the Mekong and Tonle Sap Rivers and swell the Great Lake to about four times its dry season size (MRC 2002). For one to four months, the lowlands around the Tonle Sap Lake and the Upper and Lower Mekong areas are inundated with water. This ecological phenomenon is an important source of water and nutrients for soil fertility for agriculture and for fisheries biodiversity. These impacts complement farmers' annual food production and food security.

Flash floods occur in areas around the Tonle Sap Lake, the Mekong River and its tributaries, often with devastating consequences for agricultural crops, livestock and fisheries, transport and infrastructure, housing and health. Such floods reportedly cause agricultural losses of USD100 to 170 million each year (RGC 2009). The estimated total damage and loss caused by Typhoon Ketsana in 2009 was about USD132 million (damage of USD58 million and loss of USD74 million); 14 out of 24 provinces suffered damage and destruction, and most of the affected districts are among the poorest in the country. Figure 1 shows Cambodia wetland area (left) and the extent of flood damaged paddy (right).



Source: MAFF 2010b

Figure 1: Map of Wetlands Floodplain and Paddy Damaged by Flood, 1984-2007 (Right)

Agriculture, infrastructure and human life can be seriously damaged by flood and flash floods. The Mekong River Commission (MRC), under three IPCC emission scenarios (A1B, A2 and B1), projected that rainfall will increase during the wet season but remain unchanged or lower in the dry season. This will create more flooding in the central agricultural plains, which are already vulnerable to flooding and drought (MRC 2010: 6-8). Since Cambodia relies mainly on the agricultural sector, serious decline in agricultural production could lead to more poverty and slow down national economic growth.

Drought

Frequent natural disasters, particularly flood and drought, have hit Cambodia over the last decade. Temperature has climbed steadily from one decade to the next. The MRC calculated that the average temperature in Cambodia increased by 0.8°C from 1960 to 2005; the rate of increase per decade was about 0.20 to 0.23°C in the dry season and 0.13 to 0.16°C in the wet season (MRC 2010). Based on these estimates, it is projected that the mean temperature will have risen by 0.3 to 0.6°C by 2025, 0.7 to 2.7°C by 2060 and 1.4 to 4.3°C by 2090 (Figure 2). The expected warming will be more severe from December to June. Under the Intergovernmental Panel on Climate Change (IPCC) emission scenarios A1B, A2 and B1, it is expected that Cambodia's annual average rainfall will have increased by 31 percent by the 2090s (MRC 2010).

The temperature in some provinces has increased in the last few years and some crops have been affected. For example, in a discussion with local farmers on the past and present temperature, it was mentioned that:

> ***"We (farmers) faced drought in 2010. It was so hot and it impacted on all types of crops (rice, potatoes, cassava, banana and maize). It [drought] also happened in 2002-2003 and at that time there was no rain for the whole wet season. We lost the rice crop because there was no water (interview with farmers in Dang Kda village, Krayear commune, Santuk district, Kompong Thom province, May 2011)."***

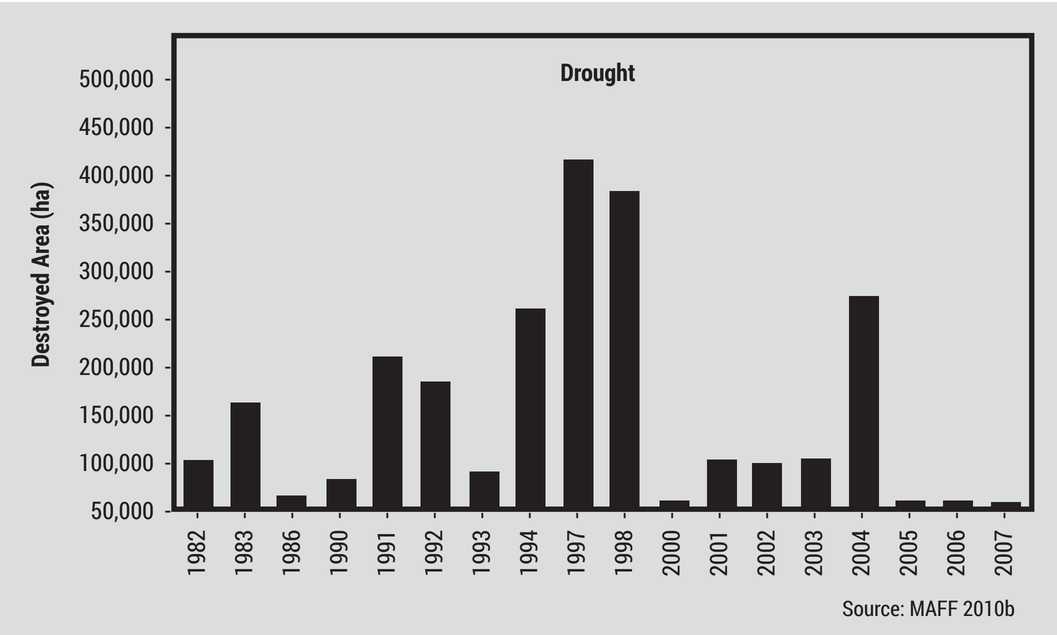


Figure 2. Total Crop Area Damaged by Drought, 1982-2007

As illustrated in Figure 2, Cambodia's agriculture was seriously damaged by drought during 1991, 1992, 1994, 1997, 1998 and 2004. The 1997 socio-economic survey of the Ministry of Planning reports that about 36 percent of Cambodia's population was living below the poverty line (RGC 2002b). The World Bank reports that the overall poverty line for Cambodia in 2007 had decreased to 30.1 percent from 34.8 percent in 2004 (World Bank 2009: 27). This reflects the relationship between drought and poverty; in 2010 approximately 20,661 ha of crops were reportedly destroyed by drought, flood and insect infestation (MAFF 2011b: 18).

Rice farming is significantly affected by drought, which mostly occurs in the middle of the wet season (known as the "small dry season"), and flood, especially at the end of the wet season (mid-October to mid-November). Such events happen almost every year in the major rice producing provinces of Prey Veng, Takeo, Kompong Cham, Kompong Thom, Battambang, Banteay Meanchey and Siem Reap provinces.

Successive droughts in 1997 and 1998 did not allow farmers to recover from the initial blow. As a result they suffered great hardship, went hungry, fell (deeper) into poverty, became sick or even died. Farmers said:

> ***"Temperature is hotter and has changed recently. There is a short cool wind but long [period of] hot air during the windy season between November and January. Drought in 2004/05 did incredible damage to the rice crop. We even lost our own seeds. Water shortage was a significant constraint to rice farming. There was no water in the canals; the scheme dried out because of the long drought. Normally the rainy season starts in mid-May, but that year it started in August. Last year, in 2010, the dry season was almost three months longer than usual (FGD with Kampang villagers, Svay Donkeo commune, Bakan district, Pursat province, 2011)."***

Agriculture is the primary source of income for the poor rural population (RGC 2002b: 37). Food insecurity and under-nutrition, due mainly to low yields and the staple diet of rice and fish, is prevalent in all rural and some urban communities (TWGAW 2007: 21). A recent report from the Ministry of the Environment (MoE) reveals that the poorest groups of people are most vulnerable to the impacts of climate change (MoE 2011: 1). This underlines the imperative to scale-up efforts to increase farmers' adaptive capacity to climate change.

Legal framework and policy on climate change

Cambodia is a signatory of the UN Framework Convention on Climate Change (UNFCCC). The National Climate Change Committee, established in 2006, serves as a policy-making body and coordinates the development and implementation of policies to address climate change issues.

Recognising that climate change is a global issue and requires individual and collective effort to adapt or mitigate its impacts, Cambodia's government has developed comprehensive regulations and policies aimed at addressing climate change issues. The government's NAPA framework is to guide the coordination and implementation of adaptation initiatives through a participatory approach and build synergies with relevant environment and development programmes. This policy prioritises a number of main projects related to climate change adaptation with regards to human health, coastal ecosystems, water resources, fisheries and the agriculture sector. A set of national forestry regulations, policies and laws was developed to validate the overall development framework for the conservation and management of the country's forest resources. On 4 July 2002 Cambodia acceded to the Kyoto Protocol, which came into force on 22 August 2002. The MoE is the national focal point for the UNFCCC and the Kyoto Protocol. The development of an effective and efficient mechanism and meteorological and hydrological networks for natural disaster prevention was prioritised in SEDP II (2001-05) (RGC 2002b:42). Meanwhile, with support from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and the Korean International Cooperation Agency, the National Green Growth Roadmap was developed to conserve and restore the natural capital base for continued economic growth within the limits posed by the environmental carrying capacity (MoE 2009).

Resultant of efforts by government, local people and the authorities, the implementation of agricultural technologies and especially government policy to promote rice production and export, the production of rice and other main crops continues to improve. Meanwhile, recognising the importance of the water sector to agriculture sector development, the national policy on water resources in 2004 emphasises the development of water reservoirs to store water as well as catchment management to help prevent floods and mitigate the impacts of natural disaster (RGC 2004: 6). In the strategic development plans for agriculture and water resources implemented in 2007 (SAW), the government sets out its clear long term vision to ensure safe and accessible food and water for all Cambodians, reduce poverty, and contribute to economic growth, while ensuring the sustainability of natural resources (TWGAW 2007). The strategy also takes into consideration the conservation of critical ecosystems and biological diversity, the protection of irrigation, rivers and lakes from agro-chemical contamination, the protection of watersheds against degradation, and the appropriate action to be taken in response to climate change and variability (TWGAW: 12).

Sustainable forest management and sustainable forest resource use is prioritised in the government's forest reform policy (RGC 2002c). Areas of denuded forest have been re-planted through tree planting programmes and other events where two to five million tree seedlings were provided to local people. Meanwhile, community forestry is being strengthened; the number of Forestry Communities had increased to 510 by the end of 2010, covering a total area of 467,884 ha (MAFF 2011a: 4). Sustainable forest management will ensure adequate forest resources for multiple benefits such as domestic consumption, fish sanctuaries, watershed protection, natural resources reserves, biodiversity and endangered species conservation and drought and flood prevention (TWGFE 2007: 2).

Cambodia has continued to develop and strengthen institutional capacity in both government agencies and community organisations to understand the impact of climate change on agriculture, forestry, fisheries, livestock, animal and human health, improved the country's capacity for long-term adaptation and resilience to climate change, and integrated these considerations into sectoral planning at all levels.

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Vietnam climate change vulnerability profile

The area of the Lower Mekong Basin (LMB) found in Vietnam includes both the Delta and the Central Highlands, two distinct regions of importance to the country's economy and culture. The results of the USAID Mekong ARCC Climate Change Impact and Adaptation Study indicate these regions will experience pronounced changes under future climate conditions related to: significantly higher temperatures, changes in the extent and distribution of rainfall, and sea level rise (SLR).

Key findings include the following:

- Annual mean temperature will rise by 3°C with daily maximum temperatures exceeding 40°C in some years; expected ramifications include significant decline in crop yields, reduced livestock productivity, and loss of NTFPs
- Annual rainfall will increase in the Vietnam portion of the LMB with wet season rainfall increasing up to 20% in the Central Highlands; the increased rainfall will cause widespread flooding during already wet periods with associated effects such as landslides, loss of crops, and reduction in yield
- Relatedly, extreme rainfall events and associated flooding will occur more often. For example, in the Central Highlands, the number of large rainfall events (exceeding 100 mm/day) is expected to double in frequency compared to baseline occurrence

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This article was drawn from a previously published material entitled *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin*: Summary Report (February 2014)". See sourcebox at the end of this article for a complete reference to the original article.

- Meanwhile, dry season months will generally become drier, prolonging water stress; in the Delta, for example, drought will occur 80% of the years in April compared to 60% under baseline conditions
- The compounded effects of SLR and increased rainfall throughout the LMB catchment during the wet season will result in annual floods of significantly greater depth and duration in the Delta.

Delta

The delta encompasses several distinct agro-ecological zones including freshwater alluvial wetlands along the upper portion of the Mekong's distributary channels; acidic peatlands to the west and east of the Mekong channels; and mangroves and saline coastal areas to the south. These three zones drive some marked differences in crop types and calendar in the delta. For example, in the freshwater zone, intensive triple rice crop farming is prevalent, while along the saline coastal zone, an annual rice-shrimp rotation is more common.

The Mekong Delta flood regime

SLR and increasing average flood volumes along the Mekong mainstream will increase the depth and duration of average floods in the Mekong Delta. Large areas of the delta that were historically rarely or never flooded to depths of 1.0 m and 0.5 m are projected to be regularly inundated to these levels. Maximum flood depths are projected to increase by over 1.0 m with the highest increases along the South China Sea coastline.

The culmination of increasing average flood flows and SLR will significantly alter the flooding regime of the delta as described below:

- Approximately 19% of the total delta area (600,000 ha) that historically was rarely or never flooded to a depth of 1.0 m will experience floods at this level or greater for four or more days during an average flood year.
- The area of the delta that is rarely or never flooded to a depth of 0.5 m or greater during an average f lood year will change significantly — from nearly 60% to only 10% of the total delta area (1.9 million ha to 300,000 ha).
- There will be a sharp increase in the area of the delta that is inundated to 0.5 m for over 121 days from 75,000 ha to close to one million ha.
- During an average flood year the area of delta flooded to over 1.0 m depth will increase from 45% to 57% under projected climate conditions — an increase of over 650,000 ha.

Climate change threats and sectoral vulnerabilities in the Mekong Delta

As SLR increases in the future, some areas of the delta that were not previously affected by salinity intrusion will become so, particularly during the dry season from January to April. Such a change will require the use of saline-tolerant rice varieties or a reduction in rice production from three to two rice crops per year. Without saline-tolerant varieties, rice yields could decrease by almost 50% in the case of mild saline water intrusion.

In provinces such as Kien Giang, Bac Lieu, and Ca Mau where seasonal salinity intrusion is common, salinity control infrastructures (embankments and sluice gates) have been developed to protect and maximize rice production in freshwater areas. With increasing SLR, these areas will be more affected by saline intrusion possibly requiring a shift in the cropping system and cropping calendar and a switch to brackish water aquaculture.

As outlined above, SLR will also affect the duration and amplitude of the delta flood regime. Extreme flooding events or early flooding in August has been known to affect the harvest of the second wet season rice crop. Rice production will be increasingly affected by excessive flooding in the tidally inundated areas and through longer flooding periods. These adverse impacts could affect all three cropping seasons.

Climate change related impacts to the Mekong Delta's fishery include increased temperatures, fluctuating salinities, and excess flooding. Increased temperatures can result in compromised water quality within aquaculture ponds. Increased flooding during the rainy season will require higher pond embankments and increased farm construction and maintenance costs. Flood events can also result in dramatic swings in salinity levels, negatively affecting shrimp production.

Central Highlands

The Central Highlands of Vietnam is a dynamic agricultural region, with both traditional systems based on rainfed rice farming and a more recent industrial agriculture based on rubber, cassava, maize, sugarcane, and robusta coffee production.

Coffee production in the Central Highlands is mostly concentrated in Gia Lai and Dak Lak Provinces, which are well suited to coffee growing as a result of climate and soil conditions.

During the past decade, the planted area of irrigated rice, maize, cassava, and sugarcane has also been expanding in provinces such as Gia Lai and Dak Lak. In Gia Lai Province, for example, the area planted with cassava has grown by about 13% per annum for the last 10 years. A similar rate of growth is found for maize (10% p.a.). These trends are the result of growing market demand and higher prices for commercial crops.

Climate change threats and sectoral vulnerabilities in the Central Highlands

Both the industrial and traditional agricultural systems of the Central Highlands will be vulnerable to changing climate factors. Significant increases in daily maximum temperatures (for example, up to 5°C higher during the wet season in Gia Lai), as well as changes in the frequency and intensity of extreme rainfall events will have significant implications for all livelihood sectors. Rainfall in the 3S basin is predicted to increase during the wet season by 11%, and decrease by as much as -10% during the dry season. Crops such as rice and robusta coffee will face severe threats from high temperatures during their growth cycle. Increased temperatures will also induce higher water demands particularly during the dry season, which is projected to get even drier in the future. Without adaptation, crop yields will be notably affected; for example, significant areas in the Central Highlands are predicted to be less suitable for cassava, robusta coffee, and rubber culture by 2050 assuming continuation of current agricultural systems and practices.

The ongoing industrialization of crops in the hill terrain of the Central Highlands has resulted in negative environmental consequences such as erosion and reduced soil fertility. The increasing frequency and intensity of extreme rainfall events that is projected for this region will only exacerbate these issues. Rainfall events larger than 100 mm/day are projected to double in frequency by 2050 in Gia Lai, for example, resulting in more flooding in narrow upland valleys, increasing erosion and landslides, and the washing out of crops.

Meanwhile, expansion of the number of farmers raising fish in small ponds and rice fields in the Central Highlands will likely continue as wild fish catches decline due to hydropower development. However, weather events such as droughts and flash flooding may present farmers with challenges for maintaining infrastructure and stocks as these extreme events continue to become more frequent.

Livestock concerns include compromised productivity of both small-scale and commercial pig systems due to increasing temperatures. Reproduction rates and natural disease immunity will decline as the animals are stressed due to factors such as water shortages and lack of suitable ventilation. Flash flooding will affect cattle production due to herd loss and increased spread of disease.

Potential adaptations options

Agriculture

Adapting the agriculture sector to climate change in both the Mekong Delta and Central Highlands will involve a mix of strategies, possibly including:

- Strengthening the resilience of both rainfed and irrigated rice-based systems through adoption of improved varieties and better management practices and reducing vulnerability to extreme climate events. This could include the use of specific varieties to mitigate the impact of flooding and extreme heat, as well as varieties that are tolerant to saline water.
- Adopting/improving water efficiency and water management practices (water harvesting, small-scale irrigation, etc.) in drought-prone areas such as in the Central Highlands in order to alleviate the impacts of water shortages.
- Improving soil fertility and soil management of both cash and subsistence systems such as improved erosion control techniques and intercropping.
- Promoting agricultural diversification and mixed farming systems to mitigate current reliance on monocultures.

Livestock

The improvement of livestock development and resilience to climate change falls into five broad strategies:

- **Nutrition:** The quality and quantity of feed production, storage, and the nutritional balance of diets needs to be increased to reduce undernourishment.
- **Disease resistance:** Internal resistance needs to increase to reduce the threat of disease through improvement of nutritional status, body condition, and vaccination levels. It also requires improved biosecurity to prevent the movement of diseases onto and off farms and to reduce the risk of pathogens entering the herd or flock.

- **Housing:** Location and design should maximize natural ventilation and minimize exposure to extreme events.
- **Production planning and offtake:** Reducing inbreeding, earlier weaning, and strategic offtake plans can increase resilience of livestock systems.
- **Access to markets:** Improved access to input and output markets and producer organizations would reduce input costs, increase prices received, and reduce price volatility.

Fisheries

Aquaculture—due to its diversity of systems, scales of production, inherent manageability, and control of environments—potentially offers more scope for adaptation to climate change than capture fisheries. Adaptation strategies for aquaculture may include:

- pond aeration to mitigate the effects of increased temperature;
- on-site water storage to reduce the risks of reduced water availability during the dry season;
- re-use of pond water also for water conservation and to mitigate the release of effluents to the environment;
- strengthening of embankments to protect against flooding will be necessary for ponds in many areas;
- diversion canals may also have to be dug to channel water away from vulnerable pond areas; and
- more climate-friendly systems, (e.g., tiger shrimp/crab production in mangrove replanted areas of the delta), should be utilized and promoted more widely.

Regardless of the livelihood sector, successful adaptation will require flexibility and a diversity of approaches to adapt to shifting conditions.

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Impacts of climate change on Vietnam fisheries

Introduction

The fishing sector is vital to Vietnamese prosperity and important to all nations bordering the South China Sea. China, Thailand and Vietnam, accounted for 80 percent of world fishery production in 2008 and 50 percent of fishery export value. In 2009, Vietnamese fisheries accounted for 6 percent of gross domestic profit. In 2010, 7.4 percent of economically active people were engaged in fishing, the second highest percentage worldwide after Fiji. Vietnam rose to the position of the fifth largest exporter of fish and related products between 1998 and 2008 when the catch was valued at nearly US $5 billion. A flourishing aquaculture industry rather than increases in offshore capture fisheries explains much of its rise. In 2007, aquaculture production surpassed capture fisheries. Pangasius, a catfish species and marine and freshwater prawns comprise the majority of exports in this sector.

Vietnam's capture fishing grounds are vast. The UN Convention on the Law of the Sea (UNCLOS) grants nations the right to declare an Exclusive Economic Zone (EEZ) of 200 nautical miles from an established coastal baseline over which it has exploitation rights to all natural resources. Vietnam's EEZ encompasses more than 1 million square miles, including 3,000 islands and 2000 species of fish: 130 have high economic value.

This article was drawn from previously published material entitled *Climate Change and Vietnamese Fisheries: Opportunities for Conflict Prevention* by Marcus DuBois King. Refer to the source box towards the end of this article for a complete reference to the original article.

Eighty percent of the world's fish stocks are overfished or at maximum capacity. This situation is especially evident in the South China Sea where coastal fishing grounds have been depleted to 5-30 percent of their unexploited stocks. Consistent with this trend, unsustainable fishing practices have been confirmed in local areas within the Vietnamese EEZ. A large amount of the over withdrawal can be attributed to the incursion of foreign fishing vessels. Declining yields have been exacerbated by environmental destruction of many kinds including that associated with tsunamis and cyclones. These stressors limit Vietnam's options for maintaining food security and could increase the likelihood of international clashes over fishing rights.

Climate change: Physical impacts

Vietnam is one of the developing countries most exposed to climate change by nature of its geography. Twenty four percent of Vietnam's population lives in coastal districts. Storms and related damage from floods and tidal surges are among the most significant impacts. Coastal mangroves, salt marshes and coral reefs – critical to breeding marine life – are all endangered. Warming ocean temperatures associated with climate change will also change migratory patterns of fish in the open sea. Fish stock scarcity caused by altered migration patterns is compounded by over-fishing.

Worldwide, climate change-driven changes in the distribution of sea life are expected in every marine ecosystem but the exact magnitude and extent of effects are largely unknown due to the immaturity of scientific analytical approaches. However, evidence from a meta-analysis of studies on range shifts of aquatic species published in 2011 in the Journal Science by I. Ching et al. (2011) has significant implications for Vietnam. Northern migration of fish stocks into waters claimed by China is the most concerning trend. It finds that as ocean temperatures near the equator rise, species in the South China Sea are migrating to colder waters in higher latitudes at a rate of approximately 17 km per decade. A newer study from the journal Nature confirms these results. More than 89% of 29,000 observational data series from 75 studies demonstrate the consistency of worldwide migratory patterns toward the north or south poles in response to warming temperatures.

Worldwide, climate change-driven changes in the distribution of sea life are expected in every marine ecosystem. New scientific analytical approaches are improving our understanding of the magnitude and extent of these effects. A meta-analysis of studies on range shifts of ocean aquatic species in the Journal Science by I. Ching et. (2011) al finds that more than 89% of 29,000 observational data series from 75 studies demonstrate the consistency of worldwide fish migratory patterns toward the north or south poles in response to warming temperatures. A 2013 study from the journal Nature confirms these results. New research in the journal Science in June 2015, amplifies these findings by demonstrating that lower oxygen caused by warming is putting too much physiological strain on marine animals living closest to the equator also driving species toward the poles from tropical ocean waters. As temperatures rise, fish metabolisms speed up increasing the demand for the scarce oxygen. Species in the South China Sea are migrating to colder waters in higher latitudes at a rate of approximately 17 km per decade. All of these

Table 1. Major physical effects of climate change on Vietnamese fisheries.	
Cyclones, typhoons	Based on a range of models, it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and heavier precipitation associated with increases of tropical sea-surface temperatures.
Flooding	Coastal areas, including the heavily-populated Mekong megadelta region, will be at greatest risk due to tidal surges and sea level rise.
Ocean acidification	Progressive acidification of ocean waters destroys corals and their dependent species. Vietnam has a limited reef system but fish species migrate northward from the fragile Coral Triangle reef system.
Rising temperatures	Shifts in ranges and changes in algal, plankton and fish abundance are associated with rising water temperatures, as well as related changes in salinity, oxygen levels and circulation.

Sources: IPCC 2007; Daw, et al. 2009; I-Ching, et al. 2011.

findings have significant negative implications for Vietnam. Northern migration of economically vital fish stocks into waters claimed by China is an emerging security concern. Climate change will also deplete aquaculture yields. Global aquaculture is concentrated in the world's tropical and subtropical regions, with Asia's inland freshwaters accounting for 65 percent of total production. In Vietnam, freshwater, coastal and offshore open water are all suitable environments for aquaculture. However, aquaculture production is concentrated in the Mekong River Delta where sea-level rise and associated surges are causing harmful saline intrusion into brackish and freshwater hatcheries. Extreme weather events such as floods damage aquaculture farms by displacing water, spreading disease, and destroying infrastructure (Table 1).

Climate change: Socioeconomic impacts

While peer-reviewed physical science identifies likely fish stock migration in the South China Sea, the socioeconomic implications of these changes have not been examined. The Notre Dame Global Adaptation index (ND-GAIN) compares a country's level of vulnerability to climate change to its readiness to deal with these impacts. As the 77th most vulnerable country and the 63rd least ready of 177 countries in the index, Vietnam faces significant challenges but there is also room for optimism that Vietnam can increase its readiness. Vietnam has moderate capacity to adapt to climate change given its status of economic development, relatively good governance a part of which is some climate change adaptation planning in the federal level. However continued reliance on declining fisheries may reduce Vietnam's moderate adaptive capacity with serious negative implications for economic development and food security.

It is hard to overstate Vietnamese reliance on fisheries. A comprehensive study by Malone et al. (2008) of the importance of fisheries to national economic and food security ranks Vietnam as the most sensitive country in the World. This study ranks Vietnam as 24th in the world in terms of relative national economic vulnerability specifically to climate change-driven impacts on capture fisheries.

These findings alone should send a resounding warning to Vietnamese policymakers about the need to rapidly develop adaptive measures to maintain the viability of fisheries. However, As noted, aquaculture has become an increasingly important source of livelihood for ethnic minorities, particularly the Thai, Tay, and Sedang, three of the 54 distinct ethnic groups recognized by the Vietnamese government. Households belonging to ethnic minorities are generally poorer than those of ethnic majorities. A 2011 survey found that reliance on aquaculture was a significant factor in Vietnamese minorities' vulnerability to poverty.

Vulnerability is defined as exposure to climate change, systemic natural resource resilience, degree of dependence of the national economy upon social or economic returns from fisheries and the extent to which adaptive capacity offsets.

fishers who already live in conditions of poverty are facing an evolving political system where economic reform is removing social safety nets associated with the formerly centrally-planned economy. This economic adjustment suggests that conditions will likely worsen for the rural poor including subsistence-level farmers and fishers before they get better.

It is reasonable to conclude that shifts in the distribution of species associated with warming of the oceans will have the greatest impact on the food security of poor (or artisanal) fishermen. These fishermen use boats, often without motors or navigational technology, which have a range of only a few miles offshore. The waters closer to the Vietnamese coastline are warming at an higher rate so that fish stocks are moving further out to sea, possibly beyond the range of artisanal fishermen. Another concern is that every major typhoon destroys an increasing number of small fishing boats and homes faster than they can be replaced.

Depletion of the fisheries and resulting economic damage may be a "push-factor" for migration. For Vietnamese people, expected income differentials and the anticipation of better public services are contributing factors to inter-provincial migration from rural to urban areas. For example, poor fishers in Ca Mau Province are reacting to loss of income resulting from a decline in off-shore fisheries by migrating to other provinces. The proportion of overall migration to urban centers is quite large. Population concentrations in urban areas are more susceptible to natural disasters such as typhoons.

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Source: Climate Change and Vietnamese Fisheries: Opportunities for Conflict Prevention

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By: Dr. Marcus DuBois King
Advisory Board Member
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LAO PDR Climate change vulnerability profile

The Lower Mekong Basin (LMB) encompasses the major part of Lao PDR and its diverse physiographic regions including the northern highlands, which are the uplands extending through northern Lao PDR, northern Thailand, and Myanmar; and the Annamites, a high mountain range which forms much of the border between Lao PDR and Vietnam. The LMB portion of Lao PDR also incorporates significant stretches of alluvial plains along the Mekong mainstream, as well as the ecologically unique areas known as Siphandone (literally "four thousand islands") and the Khone Phapeng Falls that are situated just upstream of the border between Lao PDR and Cambodia.

This article was drawn from a previously published material entitled *USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin*: Summary Report (February 2014)". See sourcebox at the end of this article for a complete reference to the original article.

Key findings include the following:

- The central and northern Annamites region of Lao PDR will experience some of the largest relative increases in precipitation that are projected for the LMB; more precipitation during the traditional growing season will impact crops through increased flooding, waterlogging of soils, and higher incidence of fungal disease and pests.
- Large rainfall events (greater than 100 mm/day) will occur more frequently. In Khammouan Province, for example, such events will increase in frequency from once every 2.5 years to once every 2 years. This increase in large-event frequency will intensify costs and damages related to associated calamities such as flooding and landslides.
- Daily maximum temperatures will rise by roughly 2°C to 3°C in Lao PDR with higher increases to the south; in Champasak Province, for example, the average daily maximum temperature will rise from 33°C to 36°C. During the more extreme years, temperatures are expected to exceed 44°C. This increase in both average and extreme temperatures will have potentially devastating impacts on crops, livestock, and human health.

Annamite Mountain Range/Central Lao PDR

Khammouan Province in Central Lao PDR is projected to experience some of the largest relative increases in precipitation within the LMB with annual precipitation increasing by 8-18%.

Monthly precipitation is projected to increase for all months in Khammouan except during January and February. Relative increases in rainfall will be highest during the months of April, May, and September with a >20% increase in monthly precipitation. In terms of absolute values, this equates to an additional 28 mm, 73 mm, and 74 mm for April, May, and September, respectively. Annual rainfall in Khammouan is projected to increase by 335 mm (2,610 to 2,945 mm/yr).

The projected changes in the timing and extent of rainfall in Central Lao PDR will present challenges to livelihood productivity such as changing seasonality and an earlier start to the growing season; increased exposure to risks such as flooding, landslides, and waterlogged soils; and the potential for heightened spread of disease.

In Khammouan, there will be a positive shift of 2°C in average daily maximum temperatures throughout the year. The increase will be more pronounced, however, during the growing season. For example, during July and August daily maximum temperatures for a typical year are projected to hover around 30°C under climate change compared to around 27°C under baseline conditions. During extreme years under climate change, temperatures will occasionally exceed 40°C during this same period in the growing season.

Climate change threats and sectoral vulnerabilities in Central Lao PDR

The vulnerabilities of the main crops cultivated in Central Lao PDR are related to effects from extreme rainfall events and increased precipitation, as well as increased temperature (Table 1). In Khammouan Province, for example, the farming system in upland areas will be strongly affected by the increase in rainfall and extreme events, lowering yield and increasing rates of erosion. Lowland areas will face higher incidences of floods and associated damages. The recent development of cassava culture will likely stop as the province will be less suitable for its cultivation and a shift of crop cultivation will probably be required.

Table 1: Main threats and vulnerability for crops in Khammouan Province, Lao PDR.

Vulnerable Crop	Threat	Impact Summary	Vulnerability
Lowland rainfed rice	Increased temperature	Increased temperature may impact productivity and lower yield.	High
Lowland rainfed rice, Cassava, Maize, Sugarcane	Flooding, flash flooding, and storms	Increasing frequency of rainfall events of >100 mm/day with a maximum of 200 mm/day expected; high storm frequency will increase the threat from rain events.	High
Cassava, Maize	Increased precipitation	Increased monthly precipitation of 5% to 27% between April and November, Monthly precipitation above 500 mm in June, July, and August (in August, monthly precipitation will reach 700 mm). Threat will be accentuated on heavy soil prone to waterlogging.	High

- Due to the topography of the region, with both mountainous areas and floodplains, extreme climatic events that involve storms and heavy rainfall above 100 mm per day will increase the threat for lowland rainfed rice, maize, cassava, and sugarcane. Climate suitability was found to be lower for these crops by 2050 as a result of projected increases in precipitation.
- Maize yields are expected to decline by 5.3% compared to the 2010 baseline. However, maize production remains a limited percentage of the agriculture sector in Central Lao PDR and this change in yield will not drastically affect the sector.
- Cassava and sugarcane will be threatened by increases in precipitation and higher incidences of extreme climatic events although sugarcane will be less affected by waterlogging compared to cassava. Rubber will benefit from higher rainfall due to a shortened drought period, although some decline in suitability is expected within this region
- Fisheries in Central Lao PDR will be affected by increased temperatures and changes in rainfall patterns. Migratory white fish may be impacted by the loss of suitable refuge pools due to higher temperatures and decreased precipitation during a portion of the dry season. Higher temperatures will affect the water quality of aquaculture ponds while increased flash flood events will decrease stocks and impact pond infrastructure.
- Livestock impacts include reduced reproduction and immunity due to heat stress, and secondary impacts related to decreased fodder availability. Increasing flood events will accelerate the spread of disease and herd loss. In Central Lao PDR, smallholder cattle/buffalo systems are most vulnerable to temperature. The effects of an incremental increase in temperature will be limited as stock will gradually become accustomed to high temperatures. But extreme temperatures ('snaps') may have direct impacts on animal value, productivity, and resilience to disease.

Champasak and Southern Lao PDR

Champasak Province in southwestern Lao PDR is characterized by a specific agro-system, including the Bolaven Plateau (in the northeast corner of the province) that supports smallholder, rainfed Robusta coffee culture; and the Mekong corridor where there is development of commercial agriculture. The rubber concession covers a large area of the province and cassava culture has expanded in recent years. Crops in Champasak Province will face threats from increased precipitation (+175 mm/yr) and temperature (+2.5°C mean annual temperature) that will affect several crops' yields. Farming systems in the province for both smallholder and commercial plantations will face radical changes in terms of climate suitability in their production systems.

Under baseline conditions, average maximum temperatures along the Mekong corridor in southern Lao PDR range from roughly 30°C to 32°C during the growing season. Under climate change, we can expect an increase in wet season temperature of about 3°C. Growing season temperatures will therefore approach 35°C on a more routine basis, which will result in significant stress on agricultural crops and other livelihood systems.

Climate change threats and sectoral vulnerabilities in Southern Lao PDR

Table 2 outlines the main threats and vulnerabilities for crops in Champasak Province, Lao PDR.

- Irrigated rice is cultivated by 20% of the farmers in this region and this crop will face a critical period at the end of the dry season, with a significant increase in temperature. Lowland rainfed rice will also face increased temperatures; especially early wet season rice. Crop yield modeling estimated a decrease in yield of about 5.6% for Champasak, corresponding to a drop of more than 11,000 tonnes of the annual provincial production.
- Robusta coffee, traditionally cultivated on the Bolaven Plateau, will face serious threats with extreme temperatures above 36°C occurring throughout the year. Coffee will also face the threat of more frequent storms with heavy rainfall that may lead to flashfloods. The combined effect of increased precipitation and temperature may lead to an increase in pest occurrence and crop disease. A general decrease in suitability is predicted for Robusta coffee in southern Lao PDR.
- Cassava culture will face waterlogging if planted on soil that does not drain well and maize crops will have reduced yields due to heavy rainfall at the end of the crop season. The crop yield model estimated a drop in yield in Champasak of about 5.5% compared to the baseline resulting in a decrease of 2,000 tonnes of maize at the provincial level.
- Livestock may see reduced reproduction rates and immunity due to heat stress, and increased spread of disease and herd loss due to increased flood events.

Table 2: Main threats and vulnerability for crops in Champasak, Lao PDR.

Vulnerable Crop	Threat	Impact Summary	Vulnerability
Lowland rainfed rice, irrigated rice, robusta coffee	Increased temperature	Critical period in March, April, and May with more than 50% of daily temperatures above 35°C; this will affect irrigated crops grown during dry season. Daily maximum temperature above rice optimal zone during the wet season. Extreme maximum temperatures above 36°C throughout the year.	High to very high
Cassava, robusta coffee, lowland rice	Storms (flashflood)	Extreme events will increase in frequency and cause increased flooding.	High
Cassava, maize, robusta coffee	Increased precipitation	Total precipitation during the growth cycle will be below the upper limit (2,300 mm/yr) for cassava but above optimal zone. Precipitation above suitable range (close to or greater than 400 mm) in July and August for maize.	High

Potential adaptations options

Agriculture

Adapting the agriculture sector to climate change in Lao PDR will involve a mix of strategies, possibly including:

- Strengthening the resilience of both rainfed and irrigated rice-based systems through adoption of improved varieties and better management practices and reducing vulnerability to extreme climate events. This could include the use of specific varieties to mitigate the impact of flooding and extreme heat, as well as the shifting of cropping calendars to avoid harvest during periods of high rainfall.
- Improving soil fertility and soil management of both cash and subsistence systems such as improved erosion control techniques and intercropping.
- Promoting agricultural diversification and mixed farming systems to mitigate current trends of reliance on monocultures.

Livestock

The improvement of livestock development and resilience to climate change falls into five broad strategies:

- **Nutrition:** The quality and quantity of feed production, storage, and the nutritional balance of diets needs to be increased to reduce undernourishment.
- **Disease resistance:** Internal resistance needs to increase to reduce the threat of disease through improvement of nutritional status, body condition, and vaccination levels. It also requires improved biosecurity to prevent the movement of diseases onto and off farms and to reduce the risk of pathogens entering the herd or flock.
- **Housing:** Location and design should maximize natural ventilation and minimize exposure to extreme events.
- **Production planning and offtake:** Reducing inbreeding, earlier weaning, and strategic offtake plans can increase resilience of livestock systems.
- **Access to markets:** Improved access to input and output markets and producer organizations would reduce input costs, increase prices received, and reduce price volatility.

Fisheries

Due to its diversity of systems, scales of production, inherent manageability, and control of environments, aquaculture potentially offers more scope for adaptation to climate change than capture fisheries. Strategies for the fisheries sector include:

- Pond aeration to mitigate the effects of increased temperature;
- On-site water storage to reduce the risks of reduced water availability during the dry season; Strengthening of embankments to protect against flooding will be necessary for ponds in many areas; and
- Diversion canals may also have to be dug to channel water away from vulnerable pond areas.

Regardless of the livelihood sector, successful adaptation will require flexibility and a diversity of approaches to adapt to shifting conditions.

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http://mekongarcc.net/resource/reports-usaid-mekong-arcc-climate-change-impact-and-adaptation-study-lower-mekong-basin-ful

Ariel Lucerna 2015

Cambodia climate change vulnerability profile

Introduction

The Lower Mekong Basin (LMB) encompasses the major part of Cambodia including the globally unique Tonle Sap Lake and associated floodplains; the 3S Rivers Basin, an important tributary network that drains into the Mekong; and the plains of Mondulkiri Province that border Vietnam in the southeastern part of the country.

The results of the USAID Mekong ARCC Climate Change Impact and Adaptation Study indicate that Cambodia will experience pronounced changes in rainfall and temperature patterns by 2050 with significant ramifications for ecosystems, and communities and the livelihoods that support them.

Key findings include the following:

- Annual daily maximum temperatures will rise by roughly 2°C to 4°C in Cambodia with higher increases during certain months of the year.
- Eastern Cambodia provinces such as Mondulkiri will experience some of the largest increases in temperature projected for the LMB with significant impacts on agriculture, livestock and fisheries, and non-timber forest products (NTFPs); more precipitation during the traditional growing season will also impact crops through increased flooding, waterlogging of soils, and higher incidence of fungal disease and pests.

This article was drawn from previously published material entitled *Cambodia Climate Change Vulnerability Profile* by U.S. Agency for International Development Regional Development Mission for Asia. Refer to the source box towards the end of this article for a complete reference to the original article.

- Large rainfall events will occur more frequently, particularly during the already wet rainy season. The projected rainfall in the 3S Rivers Basin, for example, will increase by 11% during the rainy season while decreasing by 3-10% in the dry season. Cambodia in general is dominated by lowland plains and plateaus; increased frequency of large storms will result in more flooding and related costs, especially in low-lying areas such as the extensive floodplains surrounding Tonle Sap Lake including southern and central parts of Kampong Thom Province.
- The projected changes in the timing and extent of rainfall in Cambodia will present challenges to livelihood productivity such as increased waterlogging of crops during the growing season, e.g. affecting lowland rice, soybean, and cassava; and increased livestock exposure to disease and flood-related population loss, e.g. affecting scavenging chickens, and smallholder cattle and buffalo. Extension of drought at the end of the dry season will impact the availability of critical fisheries habitat components such as refuge pools for migratory fish; and will reduce water quality in aquaculture ponds. Additional heat stress during the dry season will impact the productivity of NTFPs such as false cardamom, wild orchid, and rattan.

Climate change threats /sectoral vulnerabilities in the Tonle Sap Region of Cambodia

Kampong Thom Province is located in the central part of Cambodia between Tonle Sap Lake to the west and the Mekong River mainstream to the east. With climate change, daily maximum temperatures will increase between 2°C to 4°C throughout the year. Under baseline conditions, for example, daily maximum temperature for a typical year peaks in March at approximately 33°C. Under climate change, daily maximum temperatures in Kampong Thom will typically exceed 35°C in March-April, which will have serious effects on crops, livestock, and other livelihood sectors.

Increasing precipitation during the rainy season (e.g. up by 40 mm per month in September) may also have significant impacts on crops such as cassava and soybean.

Tonle Sap Lake and the surrounding floodplains are affected by strong seasonal inundation patterns; during the wet season the lake historically expands to roughly 15,000 km², while during the dry season it shrinks to approximately 2,500 km². This dynamic influences livelihoods in surrounding provinces; flooded rice fields during the wet season serve as an important small-scale fishery and provide a vital cash source to rural households. As the lake shrinks during the dry season, crops are grown for subsistence and cash. Additionally, the culture of fish in cages in Tonle Sap Lake is one of the oldest aquaculture systems known in the world and is of critical importance to local livelihoods. The downstream multi-species migration from Tonle Sap to the mainstream Mekong also supports the commercially important bagnet fishery, which is of great significance to the region's economy.

Kampong Thom Province is located adjacent to Tonle Sap Lake and is affected by flooding in the southern and central parts of the province. Rice, soybean, and cassava are the most vulnerable commodities there due to increased temperature and higher incidences of floods under future conditions. Lately, there has been an expansion of rubber cultivation in both industrial concessions and smallholder farms in Kampong Thom, which will also likely be significantly impacted by future climate conditions including higher temperatures and increased rainfall. The main threats and vulnerabilities for crops in Kampong Thom are outlined in Table 1.

- **Increased flooding may affect lowland rainfed rice at the end of the crop cultivation before harvesting, potentially resulting in total loss of the culture.** Late crops of soybean may also be affected by flooding, especially during the harvest period as they require dry conditions. More than 12,000 km² of land within Kampong Thom Province will see a decline in soybean's climate suitability by 2050. Cassava culture will also be threatened by flooding and increased rainfall and subsequent waterlogging that reduces yield and facilitates the spread of disease.

Table 1: Main threats and vulnerability for crops in Kampong Thom Province, Cambodia

Vulnerable Crop	Threat	Impact Summary	Vulnerability
Lowland rainfed rice	Increased temperature	More than 75% of the daily maximum temperature will be above the optional zone for lowland rainfed rice.	High
Irrigated rice	Flooding	More than 50% of daily maximum temperatures will be above 35°C in March and Aprill affecting irrigated rice.	High
Soybean	Decrease in water availability	Extreme maximum temperature higher than 35°C will occur during soybean crop growth.	High
Lowland rainfed rice, cassava, soybean	-	Flood prone area around the Mekong and Tonle Sap Lake in the southwestern part of the province. Monthly precipitation increase of 18% in September will result in increased waterlogging.	High
Soybean	-	Decrease in water availability will be between 4% and 10% during the crop growth period.	High

- **Increased temperatures will affect both dry and rainy season rice crops and, coupled with an increase in rainfall, the decline in yield is estimated to be about 3.6% in Kampong Thom.** This equates to reductions of output of up to 15,000 tonnes of rice in the province compared to the 2010 baseline. Increases in temperature will also affect soybean culture, leading to a drop in yield. The increase in rainfall and temperature will reduce the suitable areas of rubber, which has recently expanded in the province.
- Subsistence fishing is a critical source of food security in the Tonle Sap and surrounding floodplains, even if fishing is not a household's principal activity. Commercial fishing (including aquaculture) as a primary or secondary activity is common amongst many households. **Higher temperatures will likely affect the productivity of both capture fisheries and aquaculture in the Tonle Sap region.** Loss of dry season refuge pools in hydrologically connected rice fields, and reduced water quality in aquaculture ponds are primary concerns.
- Livestock may see **reduced reproduction rates and immunity due to heat stress, and increased spread of disease and herd loss due to increased flood events.**

The average daily maximum temperature in Mondulkiri will rise from roughly 31°C to 36°C during the dry season month of April. In more extreme years, dry season temperatures may exceed 44°C. The increase in both average and extreme temperatures will have potentially devastating impacts on crops, livestock, and human health.

Monthly precipitation is projected to increase for all wet season months in Mondulkiri, with a particularly significant increase of almost 70 mm expected for the month of October (Figure 1). Meanwhile, a reduction in rainfall is projected for the dry season months of December through April. Overall, annual rainfall in Mondulkiri is projected to increase by 173 mm (1,943 mm/yr to 2,116 mm/yr). However, the expected seasonal distribution of the rainfall will result in two distinct phenomena consisting of increased flooding during the wet season, and extended drought during the dry season.

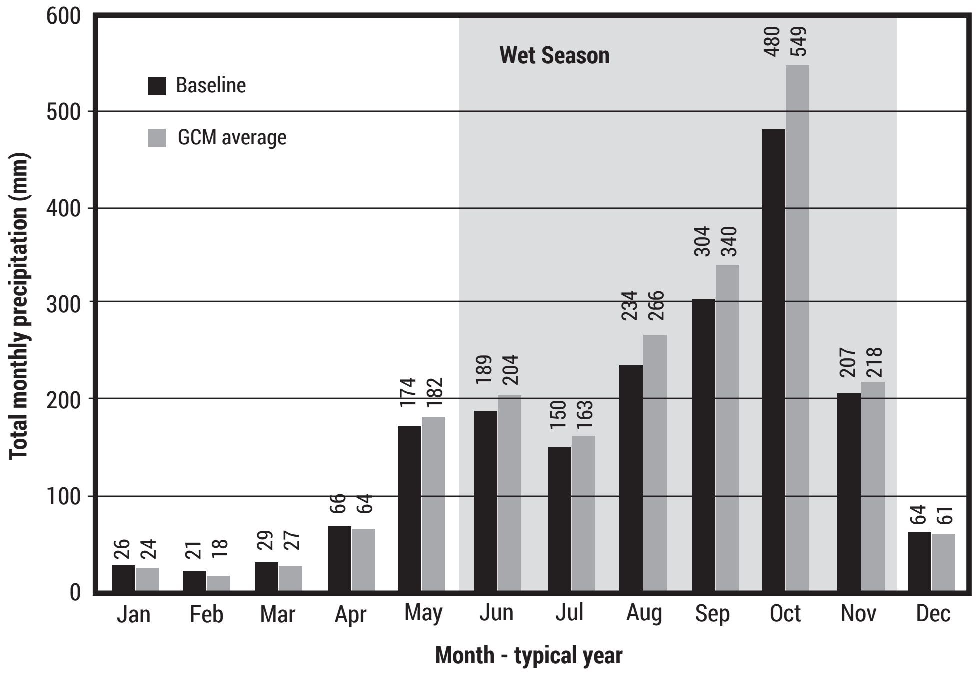

Figure 1: Monthly precipitation for a typical year in an upland area of Mondulkiri, Cambodia.

Climate change threats and sectoral vulnerabilities in Eastern Cambodia

The vulnerabilities of the main crops cultivated in eastern Cambodia are related to effects from storms and increased precipitation, as well as higher temperatures and decreased soil water availability during periods of the year (Table 2).

- Crop yield modeling estimates a decrease of 3% in rainfed rice yield in Mondulkiri, or about 1,114 tonnes per year for the province. **The climate suitability modeling showed a decrease in suitability for all the crops assessed in Mondulkiri;** particularly the industrial crops including cassava, rubber, coffee, and soybean. This could potentially strain the expansionary trend of commercial agriculture in the province and impact on opportunities for the improvement of livelihoods. Decreases in crop suitability in eastern as well as the majority of Cambodia will affect significant areas available for many crops including rubber.
- **Fisheries in eastern Cambodia will be affected by increased temperatures and changes in rainfall patterns.** Migratory white fish may be impacted by the loss of suitable refuge pools due to higher temperatures and decreased precipitation during a portion of the dry season. Higher temperatures will affect the water quality of aquaculture ponds while increased flash flood events will decrease stocks and impact pond infrastructure.
- **Livestock impacts include reduced reproduction and immunity** due to heat stress, and secondary impacts related to decreased fodder availability. **Increasing flood events will accelerate the spread of disease and herd loss.** In eastern Cambodia, smallholder cattle/buffalo systems are the most vulnerable to temperature.

Table 2: Main threats and vulnerability for crops in Mondulkiri Province, Cambodia.

Vulnerable Crop	Threat	Impact Summary	Vulnerability
Cassava, Soybean, Lowland rainfed rice	Storms and increased precipitation	Increasing frequency of storms>100 mm/ day. Precipitation above 500 mm per month in October. Increased precipitation may damage crops and create waterlogging in lowland areas that are more exposed.	Medium to high
Soybean	Decreased water availability	Decrease in soil water availability will be between 18% and 20% during the crop season creating water stress.	High
Rice	Increased temperature	Increase in maximum temperature will fall between 12% and 17% compared to baseline conditions during growth period. More than 50% of the maximum daily temperatures will be above the optimal zone for rainfed rice.	Medium
Cassava	Increased temperature	Around 15% of the days will be above 35ºC during the growth cycle of cassava.	Medium
Rubber	Increased temperature	Dry season (March to May) will have more days above 35oC as daily maximum temperatures with temperature increase of 17% in May.	Medium
Soybean	Increased temperature	Higher maximum temperature in the rainy season will limit yield. This might be a stress for soybean in the case of the early wet season crop in April or May.	Medium

Potential adaptation options

Agriculture

Adapting the agriculture sector to climate change in Cambodia will involve a mix of strategies, possibly including:

- Strengthening the resilience of both rainfed and irrigated rice-based systems through adoption of improved varieties and better management practices and reducing vulnerability to extreme climate events. This could include the use of specific varieties to mitigate the impact of flooding and extreme heat, as well as the shifting of cropping calendars to avoid harvest during periods of high rainfall.
- Improving soil fertility and soil management of both cash and subsistence systems such as improved erosion control techniques and intercropping.
- Promoting agricultural diversification and mixed farming systems to mitigate current trends of reliance on monocultures.

Livestock

The improvement of livestock development and resilience to climate change falls into five broad strategies:

- **Nutrition:** The quality and quantity of feed production, storage, and the nutritional balance of diets needs to be increased to reduce undernourishment.

- **Disease resistance:** Internal resistance needs to increase to reduce the threat of disease through improvement of nutritional status, body condition, and vaccination levels. It also requires improved biosecurity to prevent the movement of diseases onto and off farms and to reduce the risk of pathogens entering the herd or flock.
- **Housing:** Location and design should maximize natural ventilation and minimize exposure to extreme events.
- **Production planning and offtake:** Reducing inbreeding, earlier weaning, and strategic offtake plans can increase resilience of livestock systems.
- **Access to markets:** Improved access to input and output markets and producer organizations would reduce input costs, increase prices received, and reduce price volatility.

Fisheries

Due to its diversity of systems, scales of production, inherent manageability, and control of environments, aquaculture potentially offers more scope for adaptation to climate change than capture fisheries. Strategies for the fisheries sector include:

- Pond aeration to mitigate the effects of increased temperature;
- On-site water storage to reduce the risks of reduced water availability during the dry season;
- Strengthening of embankments to protect against flooding will be necessary for ponds in many areas; and
- Construction of diversion canals to channel water away from vulnerable pond areas.

Regardless of the livelihood sector, successful adaptation will require flexibility and a diversity of approaches to adapt to shifting conditions.

Source: USAID Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC)

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chapter 2

Food and nutrition security concerns in a changing climate

- Climate-smart food systems for enhanced nutrition
- The Paris Climate Agreement: what it means for food and farming
- Sustainable food systems and health: The convenient truth of addressing climate change while promoting health
- Climate change, food security and small-scale producers
- Nutrition insecurity: A major consequence of climate change
- Ensuring nutritional security in a changing climate
- Ways to enhance the adaptation to climate change variability at the village level
- Policy implications and recommendations for climate services design
- The implications of climate change for land policy
- Stepping up to the challenge: Six issues facing global climate change and food security

Food and nutrition security concerns in a changing climate

Agriculture and food production will be especially impacted by climate change, with extreme weather events expected to affect all aspects of the food value-chain, from crop yield to product quality. Decreases in production could lead to price increases for staple crops. The poorest are expected to be hit hardest, undermining already existing efforts to address undernutrition and malnutrition in these already marginalized populations. Climate change is also expected to affect food and nutrition security indirectly, through issues related to sanitation, water and food safety, health, maternal and child health care practices. Since changing weather patterns also negatively affect food availability and access, this chapter examines socioeconomic factors surrounding access to resources that are likely to increase risks among vulnerable social groups. It also highlights measures which seek to minimize disruption and build resilience to climatic shocks within agricultural systems at national and local levels.

Climate-smart food systems for enhanced nutrition

Nutrition-sensitive food systems have the potential to be climate-smart. While evidence of effective climate change interventions is still limited, there is already a good understanding of how diets and the environments in which food choices are made can be better managed in response to weather extremes and price volatility. Climate-smart actions which support nutrition entail a focus on diverse, high-quality and healthy diets. Solutions lie in the diversification of agricultural and non-farm production systems, the mitigation of climate-related stresses on crop and livestock quality, food value-chain investments to retain nutrients and reduce perishability (including greater efficiency in post-harvest storage, processing and transportation), enhancement of diet quality through more informed consumer choices, and the buffering of purchasing power in the context of supply and price shocks.

The Global Panel recommends six major policy actions to governments:

1. Include diet quality goals within adaptation targets proposed for climate action.
2. Diversify agricultural investments, factoring in the local realities of ecological suitability and comparative advantage.

This article was taken from a longer article entitled *Climate-smart food systems for enhanced nutrition* prepared by the Global Panel on Agriculture and Food Systems for Enhanced Nutrition and released in September 2015. Refer to the source box towards the end of this article for a complete reference to the original article.

3. Support greater food system efficiency so that outputs per unit of water, energy, land and other inputs are optimised and the footprint of agriculture and non-farm activities are better managed to meet both food demand and higher-quality diets.
4. Integrate measures to improve climate change resilience and the nutritional value of crop and livestock products along the value chain, from production to marketing.
5. Protect the diet quality of the poor in the face of supply shocks and growing food demand.
6. Promote the generation and use of rigorous evidence on appropriate investments along food value-chains which are resilient to climate change and also deliver positive dietary outcomes and support improved nutrition.

Climate change seen through a nutrition lens

By 2100, it is anticipated that up to 40% of the world's land surface will have to adapt to novel or partially altered climates (Williams et al 2007). Global agricultural production could fall by 2% per decade through to 2050 (based on projections of staple grain yields and livestock output), at a time when global food demand will be increasing by 14% each decade (IPCC 2014). The largest growth in demand will be occurring in low income countries, which are likely to be most negatively affected by losses in food quality and quantity through the value chain. Indeed, a growing number of projections consistently suggest that climate change will bring improved conditions for agriculture to high-latitude regions, while many parts of the tropics and sub-tropics will experience less favourable conditions and falling yields, particularly of wheat, maize and rice (Zabel et al 2014; IPCC 2014; Muller and Rovertson 2014; Piontek et al 2014). This already appears to be happening. Maize and wheat yields would have been higher in some of the world's key production zones if climatic parameters had not shifted in the past two decades. For example in China and Brazil, maize yields would be 7% to 8% higher today had climates been stable, while wheat yields in Russia would be 14% higher (Lobel et al 2011).

Besides affecting food supply, climate change may also affect diversity and nutritional value. Changes in temperature, rainfall and crop and animal disease environments will affect agricultural outputs in different ways (Kang et al, 2009; Wheeler and von Braun 2013). In general, nutrient-rich foods that are currently in short supply in many low-income settings are particularly susceptible to water constraints, pests and diseases, and temperature fluctuations (Rosenzweig 2001). The principal sources of essential micronutrients are animal-based foods, including milk, meat, eggs and fish, as well as vegetables, fruits and pulses (WHO 2013). Fruits and vegetables are very sensitive to damage and are more perishable than grains or tubers after harvest. Livestock productivity (the source of foods that are critical to young child growth and cognitive development) also tends to be impaired by lack of water and adequately nutritious fodder, as well as by heat and livestock diseases.

Recent research has also suggested that higher levels of carbon dioxide in the atmosphere may reduce the nutrient content and/or quality of various staple crops, making them less inherently nutritious (Myers 2014). If this holds across a wide range of staple foods, the potential degradation of nutrient composition would have a negative impact on nutrient adequacy among the poorest consumers.

How crop and livestock production adjusts to changing local patterns of rainfall, temperature and seasonality will strongly influence food systems and the food environment for consumers in the decades ahead. As a result, there is growing recognition of the need to assess impacts of climate change through a nutrition lens, which requires a global focus on healthy diets, "in particular on the quantity, quality and diversity of food" (FAO and WHO 2014). Healthy diets, which provide adequate, safe, diversified and nutrient rich foods, are an essential building block for physical growth and cognitive development in children (Black et al 2008). The nature of diets is influenced not only by policies relating to food production, but also by actions that affect market and trade systems, food transformation, and retail and consumer purchasing power. When policymakers consider how to mitigate climate change impacts on the food environment, they need to explore the potential for policy intervention across all domains of the food system (Global Panel 2014).

Climate change is expected to have particular impacts on the diets of poor populations in low and middle income countries across Sub-Saharan Africa and South Asia (Black et al 2013). Countries in these regions have significant numbers of people who rely on agriculture for their livelihoods, and who already carry a huge burden of malnutrition (FAO and WHO 2014; Black et al 2008; Muller et al 2011; Roudier et al 2011; Knox et al 2012; Muller et al 2014). Lower yields, combined with population growth, urbanisation, poverty reduction and hence rising food demand in those regions, will likely put upward pressure on food prices and reduce the accessibility of healthy diets for the poor—including smallholder producers who are often net purchasers of food. While food is not the only determinant of poor nutrition, diet-related health and nutrition problems represent a major burden on the social and economic development of countries in these regions, with millions of children too short for their age, tens of millions of women of reproductive age suffering serious deficiencies of vitamins and minerals, and hundreds of millions of children, adolescents and adults now overweight or obese (the incidence of which is increasing rapidly in low and middle income countries) (Black et al 2013; Global Burden of Disease Study 2013; IFPRI 2014).

It will be a challenge for countries with an existing high burden of malnutrition to improve nutrition in the context of climate change. This is because policy actions are required across the food system. They include the need to increase domestic food production efficiencies, diversify agricultural and value-chain portfolios, enhance engagement in agriculture and food trade (local, regional and global), and establish well-functioning safety nets that protect the purchasing power of the poor in both rural and urban settings. In addition, priority needs to be given to reducing greenhouse gas emissions associated with food processing technologies used in food transportation, storage, and marketing, facilitating private sector investments that will protect food supplies for all consumers, and promoting greater consumer understanding of the environmental implications of food choices (by highlighting otherwise hidden costs of production, processing and distribution).

There are many public health interventions that are known to be effective in tackling various forms of malnutrition including child stunting, maternal anaemia, or iodine deficiencies among school aged children (Bhutta et al 2013). However, there is a growing global consensus that these interventions alone will not be enough to address current levels of global undernutrition (IFPRI 2014). Nutrition-sensitive food systems which can address underlying determinants of malnutrition along the chain from food production, through marketing and processing, to retail also need to be promoted (Ruel and Alderman 2013).

However, the empirical evidence base on 'what works' in adapting and enhancing food systems to cope with climate change is still limited, largely because evidence of how much and how fast climates are changing is relatively recent. Governments the world over must prioritise rigorous assessment of how climatic conditions are evolving locally, and the effectiveness of policy and programmatic attempts to make various elements of the food system more resilient to actual and projected changes. A strong evidence base on innovation along the entire value chain is urgently needed.

> "The already-present impacts of climate change are demanding innovation and partnership in agriculture on a scale never seen before. It is not an academic discussion about some uncertain future – it is posing challenges to farmers today."
>
> *- Rachel Kyte (2015), Global Panel member; Vice President and Special Envoy, Climate Change Group, World Bank Group; and Chair of CGIAR Fund Council, Nutrition-sensitive agriculture must also be climate-smart*

But policymakers do not need to wait for new evidence before taking action to enhance, sustain and diversify their production systems and diets. There are already numerous examples of ways in which food systems can be made more resilient to present day threats. For example, researchers have been actively developing and promoting the use of drought tolerant strains of staple crops such as wheat and maize, salt tolerant and faster maturing variants of rice, heat tolerant strains of livestock, and pest-resistant legumes (such as peanuts) (CIAT 2015; Mottaleb et al 2012; Thornton and Herrero 2014). Ongoing research seeks to reduce on-field and post-harvest losses arising from moulds and diseases, while work on nutrition-sensitive value-chains seeks to promote nutrient conservation and/or nutrient fortification through processing (Gelli et al 2015). Other researchers seek to increase the nutrient content (vitamins and minerals) of staple and non-staple crops by making them more nutrient-dense, which often carries benefits for the vitality of the crop plant itself as well as for end consumers (Global Panel, 2015; Welch and Graham 2004).

Underlying all such adaptation and mitigation-focused research is an understanding that just producing more food in coming decades will not be sufficient to meet demand, protect supply, or enhance diets (African union 2014). Greater efficiency, diversification and a focus on quality are all needed to meet the multiple goals that hinge on more nutritious and more sustainable food systems as a whole. Thus, nutrition-enhancing policy interventions need to include not only the diversification of agricultural production, but also improved marketing and trade that supports access to nutritious foods and the commercial development of nutritious food products and their consumption (more diverse diets). Indeed, greater attention is needed for the diversification of, and enhanced resources efficiencies in, all forms of non-farm livelihood activity. In other words, rural households should have the ability to invest their time and resources in activities that reflect their competitive advantage across different income-earning opportunities (Barrett et al 2001).

Actions to protect consumers from food price volatility by improving marketing and storage efficiencies as well as investments in targeted safety nets that are able to smooth consumption through periods of crisis would be essential. Attention in food price policies to incentives that can encourage greater availability and accessibility of nutrient-rich foods to all consumers could also have potential value.

The Global Panel suggests six major areas of policy action which can be both climate-smart and nutrition-sensitive:

1. Diversification of agricultural investments

In the past few years, climate-smart agricultural initiatives have been promoted in Burkina Faso, Nicaragua, and Indonesia aimed at supporting food system adaptation to, and mitigation of, impacts of climate change (FAO 2013). So far, those actions have focused on raising agricultural productivity and incomes, adapting and building resilience to climate change, and reducing greenhouse gas emissions (Pye-Smith 2011). A key opportunity is to explore the potential of these and similar initiatives to improve nutrition.

Crop diversification using locally adapted varieties is widely promoted as a strategy that can support the adaptive capacity of most food systems (IPCC 2014; Thornton et al 2011; Muller 2013; Waha et al 2013; Davis et al 2012). Some programmes have begun to build resilience to weather variability into farm production systems. For example, the Adaptation for Smallholder Agriculture Programme in Bolivia has used indigenous knowledge related to climate change adaptation to support the introduction of varieties that can be grown at higher altitudes if necessary. That intervention has supported a transition from almost exclusive potato production to a more diversified portfolio that includes fruit tree production, which has increased market penetration for smallholders. Similarly, the promotion of agroforestry systems in the Sahel has the potential of bringing multiple benefits to smallholders, including nutritional gains achieved by growing non-traditional trees that are resilient to drought and heat, such as Adansonia digitata or Baobab, whose leaves and fruit offer many high-quality nutrients, and Vitellaria paradoxa, which provides fruit during the lean period for consumers (IFAD 2014).

Crop and animal diversification generally enhances dietary diversity (Torheim et al 2004; Jones et al 2014). Diet diversity represents a fundamental aspect of dietary quality since the consumption of multiple types of foods typically reflects a higher quality diet that is more likely to meet consumers' nutrient needs (Bhutta et al 2013). However, recent trends show global convergence towards homogenous diets. This makes the global food supply more susceptible to threats such as pests, diseases, and weather shocks which are likely to increase as a result of climate change (Khoury et al 2014).

Thus, growing a wider diversity of crops and livestock and adopting more pest, disease, drought and/or heat tolerant varieties can support climate-resilient agriculture while also facilitating consumer diversity (if those foods reach markets at prices affordable to the poor). Policymakers should promote diversification of both products and means of production (actively supporting incentives for farmer innovation and investment), rather than maintain a long-standing reliance on a narrow range of agricultural outputs that are sensitive to conditions over which smallholders have limited control.

2. Investments in efficiency across the food system to support resiliency and nutrition

Enhancing diets requires going further than producing more of the same. Even higher output of existing agricultural commodities produced in conventional ways will not suffice to enhance nutrition, nor will it be enough to achieve climate adaptation. Greater efficiencies are needed, along with greater diversity, to improve the resilience of food systems. The adoption (as locally appropriate) of no-tillage/green mulch cropping, fine-tuned spot irrigation and enhanced water control, calibrated applications of fertiliser, rotation with nitrogen-fixing ground crops and innovations in integrated pest management can greatly improve output efficiency per unit of inputs (whether it be water, crop nutrients or energy) (FAO 2013). These practices also contribute to reducing greenhouse gases per unit of food.

Heterogeneity in production systems needs to be taken into account when seeking efficiency gains. Staple foods must be enhanced, in terms of seed quality and how they are cultivated, to maintain yields under changing climate and to be more resilient to pests and disease. For nutrient-dense non-staples, such as animal source foods and vegetables, the promotion of enhanced varieties/species may be possible but resource efficiency along the supply chain (conservation, processing, and packaging) is where most attention is needed. Protection and enhancement of biodiversity can also promote heterogeneity in less-traditional forms of agricultural output. For example, in Ethiopia the Humbo Assisted Natural Regeneration Project has focused on restoring almost 3,000 hectares of biodiverse forest cover which, according to the World Bank, has resulted in income generation for smallholders who now sell agroforestry products, such as honey and wild fruits (World Bank 2014).

Livestock production presents an important opportunity to improve nutrition in low- and middle-income countries. There is strong evidence that consumption of animal source foods (meat, fish, dairy products and eggs) is associated with improved physical growth of children and cognitive development (Speedy 2003; Murphy and Allen 2003). While livestock production is often resource-intensive (in its high levels of consumption of water and other natural resources), and contributes to climate change through greenhouse gas production, greater efficiency in production systems can reduce the number of animals kept, while enhancing quality and output per unit (Friel et al 2009; Herrero et al 2013; Gonzalesz et al 2011; Pradere 2014; Thornton and Herrero 2010). For example, the use of improved feed supported and implemented by the East African Dairy Development programme of Heifer

International improved milk quality and supply (among 179,000 smallholder producers in Uganda, Rwanda and Kenya), as well as access to new markets through the formation of Dairy Farmer Business Associations, while reducing greenhouse gas (GHG) emissions (Thornton and Herrero 2010; Jonsson 2012).

At the same time, reducing production and consumption of meat, particularly red meat, in high-income countries would help improve health and mitigate the global impacts of climate change. (McMichael et al 2007). The policy challenge in low-income settings is to encourage both improved livestock productivity (efficiency in the conversion of water and feed into food, as well as reduced carbon footprint) and greater consumption of animal source foods by nutritionally-vulnerable groups. The challenge is to promote these aims without establishing a trend towards consumption levels of meat and dairy that are characteristic of high-income populations who suffer significant levels of diet-related chronic diseases and obesity (Delgado 2003; Bene et al 2015).

Policymakers should promote resource use efficiency across the food system, including the reduction of food waste. It is estimated that one-third of food produced for global human consumption is lost or wasted. Most of the waste in low-income countries food occurs during the early and middle stages of the food supply chain (Gustavsson et al 2011) and is mainly caused by financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities, infrastructure, packaging and marketing systems (Affognon et al 2015). A recent review found that up to 25% of maize harvested in low-income countries is lost post-harvest. This could be decreased to about 6% with the adoption of innovations for mitigation of post-harvest losses and investments in infrastructure (Affognon et al 2015). The losses rise for perishable crops, such as vegetables and fresh fruits, where up to 40% of crops do not reach the consumers (15% with interventions).

Other actions are needed to reduce the costs and economic viability of innovations in food storage (longer shelf-life and reduced perishability), processing (aimed at retaining nutrients and quality of products), marketing, and also lowering carbon emissions associated with value-chain activities wherever possible. In other words, decision-makers should prioritise actions that remove constraints and facilitate smoother operations for producers, processors, wholesalers, retailers and consumers across the entire food system. This includes greater attention to efficiency in resource use in non-farm rural activity.

"The challenges of malnutrition and climate change come together as an opportunity in agriculture. So, as we consider adopting climate-smart agricultural practices, let us also integrate nutrition. It is time for agriculture to be both climate-smart and nutrition-smart. With this approach, we have an opportunity to drive progress more sustainably and more beneficially."

- John Kufuor (2014), co-Chair of the Global Panel; Former President of Ghana

Rural households in low-income countries are typically no longer only engaged in farming. As labour and product markets continue to link remote regions of low-income countries with economic hubs of activity in high-income nations, the share of total income deriving from agriculture is declining outside of rural areas with high productivity in high-value commodities. This means that off-farm operations, which may include working for brick kilns, mining for minerals, factory work, or charcoal production, can both contribute to climate change and to incomes used to diversify food purchase choices.

More recently, initiatives focused on renewable energy have been used to increase efficiency and reduce carbon footprints along the value chain, from irrigating fields (Burney et al 2010) to drying and cooking food (Davies and Davies 2009; Wentzel and Pouris 2007). These innovations have the benefit of being responsive to the climate change agenda while simultaneously enhancing food systems in ways that support improved diets and nutrition.

3. Integrate measures to improve climate change resilience and nutrition

Recent research suggests that climate change may affect not only people's capacity to produce crops in certain parts of the world, but also impair the nutritional content of those crops as well (Myers 2014). Certain crops, including maize, peanuts, beans, and rice (Bebber et al 2013), that are less resistant to water or heat stresses are more likely to be damaged or contaminated by pests, disease and moulds, with repercussions on food quality as well as food safety (Rosenzweig 2001; Tirado et al 2010). Natural toxins produced by fungi (mycotoxins) can be highly carcinogenic to consumers, and are also increasingly linked to immune suppression in infants and impaired linear growth of children, which contributes to the heavy global burden of child stunting (Groopman et al 2014).

Current international initiatives in crop breeding are already integrating properties for resilience and nutrition, for instance through new bean varieties which are climate (heat) resilient and more nutritious. Researchers have recently identified a variety of beans that show strong tolerance to temperatures 4°C higher than the range that beans can normally tolerate (CIAT 2015). National agricultural research policies should embrace this integrated goal, pursuing their own research on local crops and animal species and adapting international seed and animal stocks to expected local conditions.

Protecting nutrients in the food supply and increasing resilience to climate change beyond productivity requires a focus on reducing post-harvest losses, enhanced storage (to protect food safety and quality of products), improved infrastructure (roads, information systems, refrigeration) that can reduce losses of high nutrient perishable goods, as well as interaction with the private sector. Engagement with the private sector is necessary to enable a successful promotion of efficient energy use in food processing and packaging, and campaigns to encourage less post-consumer food waste, which can be high in low-income settings, particularly in areas where processed packaged foods represent an important part of the diet. In addition, more efficient market infrastructure and stronger food safety regulations can also contribute to mitigating pest, disease and mould threats (Wagacha and Muthomi 2008; Hell and Mutegi 2011).

Support for new and adaptive research is urgently needed on ways to enhance and protect the nutrient content of agricultural products in the context of climate change. This includes agronomic research to improve and retain nutrients in foods important to nutritionally-vulnerable populations, but also support for technological innovation in food processing, storage, packaging and transportation.

4. Protecting diet quality in the face of supply shocks and growing food demand

Climate and economic shocks increase the volatility of food prices. When prices are high or uncertain, consumers typically respond by protecting their intake of major staples and then substituting other foods in the diet to make the most of what their purchasing power will allow them (Cornelsen et al 2014). The experience of major food price shocks of the past 15 years or so has shown that in most cases, the purchase and consumption of nutrient-rich foods, such as fruit, vegetable and meat and/or dairy products, declines in the face of a rising share in total consumption of foods that simply provide energy in the form of calories. Numerous studies have captured this standard household response to price shocks around the world, from South-East Asia in the late 1990s (Skoufias et al 2012) to South America (Ianotti and Robles 2011), Africa (Mason et al 2011) and South Asia (D'Souza and Jolliffe 2012) in the context of the global food price crises of 2007/8 and 2010/11.

Improved marketing and distribution systems are critically important to help reduce supply variability, but so too are price policies and social protection systems that can buffer effective demand and smooth consumption among the poorest consumers (Barrett 2008). Time-bound and targeted (rather than universal) food price subsidies can support consumption levels of the nutritionally vulnerable. Making rural credit more easily accessible to the poor and longer-term conditional cash transfers linked to health and education can also provide a buffer against the vagaries of prices that go hand-in-hand with climatic anomalies. That said, price and trade policies aimed at consumer protection should be informed by the potential for unintended side-effects which can distort markets and trade patterns, as well as dampen the supply response to high prices because of lower producer prices.

While it is critical to protect intakes and enhance diet diversity of the poor rural populations in time of shocks, many low-income countries are also witnessing an increasing urbanisation and a growing middle class (Tschirley et al). These trends significantly increase the demand for food, particularly for meat, fish and processed foods (Delgado 2003), which can lead to stressed food systems, high emission of GHGs, and the potential increase of obesity and non-communicable diseases (NCDs) for consumers. These trends need to be taken into account to provide availability and accessibility of food in the near future that is both nutrition-smart and climate-smart. As a consequence, a rebalancing of policy and investments from staples to nutrient-dense non-staples would be required (Pingali 2015).

Supply-side and food price shocks are likely to increase with climate change. Policymakers should support a diversification of production systems as well as products produced (incentivising innovation, including the adoption of more nutrient-dense commodities), while strengthening the resilience of food systems, from production through marketing to consumption, to withstand extreme variability of climatic conditions and an erosion of nutrient quality of foods moving up the value chain. This will need to include both public research and commercial investment in storage and transportation technologies to reduce the perishability/extend the shelf-life of nutrient-dense foods and promotion of more diverse dietary choices that incorporate nutrient-rich substitutes to common staples. Targeted protection of consumer demand through safety-nets that buffer purchasing power among poor and vulnerable populations, including public procurement of nutrient-dense foods for meals in educational and health institutions is also critical.

Greater awareness should also be promoted among consumers of the environmental, as well as economic, costs of production, processing, distribution and sale of various foods. Commercial companies are already seeking to protect consumer prices and shareholder profits from expected climate change-related impacts on natural resources (water, yields, and nutrient content) and climatic shocks that can disrupt both supply and distribution of commodities and processed food inputs. The public sector can play a role in educating and influencing consumer food choices in this wider context of system vulnerability.

5. Generate additional evidence on how agriculture can deliver positive nutrition outcomes to identify leverage points for policy

There is a growing literature on the impact of climate change on agriculture supported by better data, more advanced mathematical models, and increased computational power essential to forecast complex models. But there is a need to generate more evidence on how agriculture can deliver positive nutrition outcomes in various settings to better support decision makers. That is, research investment is needed to understand the dynamics that explicitly link investments in agriculture and desired outcomes in nutrition. There are non-linearities in such relationships, and policymakers need greater evidence-based support for policies that promote agriculture and nutrition. Such policies typically rely on a combination of innovation, technology adoption, and changes in consumers' demand. However, more attention is needed to identify the range of interventions that are possible, and their cost effectiveness, so that policy makers can focus on optimising benefits in a context of limited resources.

A key aspect of a forward-looking climate change agenda, therefore, is the generation of novel forms of rigorous evidence on 'what works' from a policy perspective that is focused on nutrition-smart food systems. The research community must prioritise knowledge gaps in this important policy area. They include the validation of individual metrics of diet quality and climate change impacts, as well as research that enhances understanding of system-wide causal dynamics along entire value-chains from production to consumption.

This will require governments and international donors to support high quality research that a) empirically elucidates the mechanisms through which climate change will affect each link in the food value chain, separately and collectively, and b) measures the effectiveness of a range of food policy interventions for promoting agriculture, marketing and processing efficiencies, improved consumer choices, dietary quality and enhanced nutrition outcomes. Most of this research will require multidisciplinary tools and collaboration among scientists, industry specialists and government policymakers. Such a commitment to integrating different disciplinary and sectorial domains will support a novel focus on the two-way processes that link global and local food system outcomes.

National commitments to global target-setting development goals should include necessary metrics relating to food system enhancements that are amenable to policy action. The collection and sharing of data will help support of national government and global development goals.

Recommendations to policy makers

About half of the world's population is at risk of being undernourished due to rising food demand and a potentially compromised supply as a result of climate change by 2050 (Dawson et al 2014). But the worst case need not materialise.

Policymakers can make a significant difference to outcomes in the coming decades by adopting a pro-nutrition lens while protecting and promoting agriculture in the face of climate change. While evidence of effective climate change actions remains scarce there is ample evidence already of how to enhance diets and food systems in the context of weather shocks and price volatility. Effective solutions lie in the diversification of agricultural investments, the mitigation of climate-related stresses on crop and livestock quality, greater resource use efficiency along value chains, and protecting diet quality in the face of supply and food price shocks. In other words, climate-smart actions which support nutrition means focussing on diverse, high-quality, healthy diets.

The six major policy actions recommended to governments by the Global Panel are:

1. Include diet quality-enhancement goals within the adaptation targets that they propose for global climate action. Upcoming global meetings will encourage governments to define nationally determined contributions to the target-setting agenda, including identifying metrics to be used to monitor progress. The more governments that include food system, diet and nutrition related issues in the climate change dialogue, the more focused policymakers will be on linking climate-smart actions with nutrition-smart metrics. The two must proceed in unison.

2. Diversify agricultural investments based on ecological suitability and comparative advantage, such that a greater variety of production systems are supported, extension programmes are sufficiently varied and at scale to meet the needs of both large and small farmers, crop and livestock production is not limited to a few potentially vulnerable agricultural outputs, and required inputs of high quality are available to all.
3. Support greater food system efficiency, so that agricultural outputs per unit of water, energy, land and other inputs are optimised and the carbon footprints of agriculture and non-farm activities are better managed to meet both food demand and higher-quality diets. This means rebalancing research and value-chain investments towards production and distribution systems that make more nutrient-dense foods available to all, and provide a greater understanding of value-chain and non-farm activities as sources of income for the rural poor. Efficiency gains should span the whole value chain, focusing on post-harvest losses, and be supported by priority investments in applied research that generates evidence on the cost-effectiveness of alternative production-to-consumption scenarios. New technology transfer and open data goals framed by the post-2015 Sustainable Development Agenda should include commitments to free dissemination of public research.
4. Integrate measures to improve climate change resilience and nutritional value by adapting crop and livestock sources of important nutrients, and their production systems, to the anticipated impacts of climate change in the form of pests, diseases, weather-related shocks, and price volatility. The building up of resilient and nutritious food systems which go beyond food production, to include enhanced storage and marketing, reduced food waste, and enhanced consumer choices, while seeking greater efficiencies throughout.
5. Protect the diet quality of the poor in the face of supply shocks and growing food demand. This can be done by the establishment of robust, targeted social protection programmes, transitory consumption-smoothing interventions, enhanced access by the poor to credit, food market information, and enhanced nutrition knowledge on which to base appropriate choices. Improving the quality of diets is central to addressing all forms of malnutrition.
6. Promote the generation and use of rigorous evidence on investments along food value-chains that are resilient to climate change while also delivering positive dietary outcomes. While evidence is accumulating on how climate change affects food production and consumption, more is needed to guide evidence-based policy making that will effectively link actions across all food system domains. Coherent research focused on policies through which different elements of climate change may have impacts on food systems, and on the cost-effectiveness of alternative actions in agriculture, marketing, processing, retail and consumer support that could offset such impacts is essential. Diet quality indices and other food system metrics should be included as part of climate-related target-setting agendas and in related surveillance systems which are established to monitor changing conditions and the effectiveness of policy responses.

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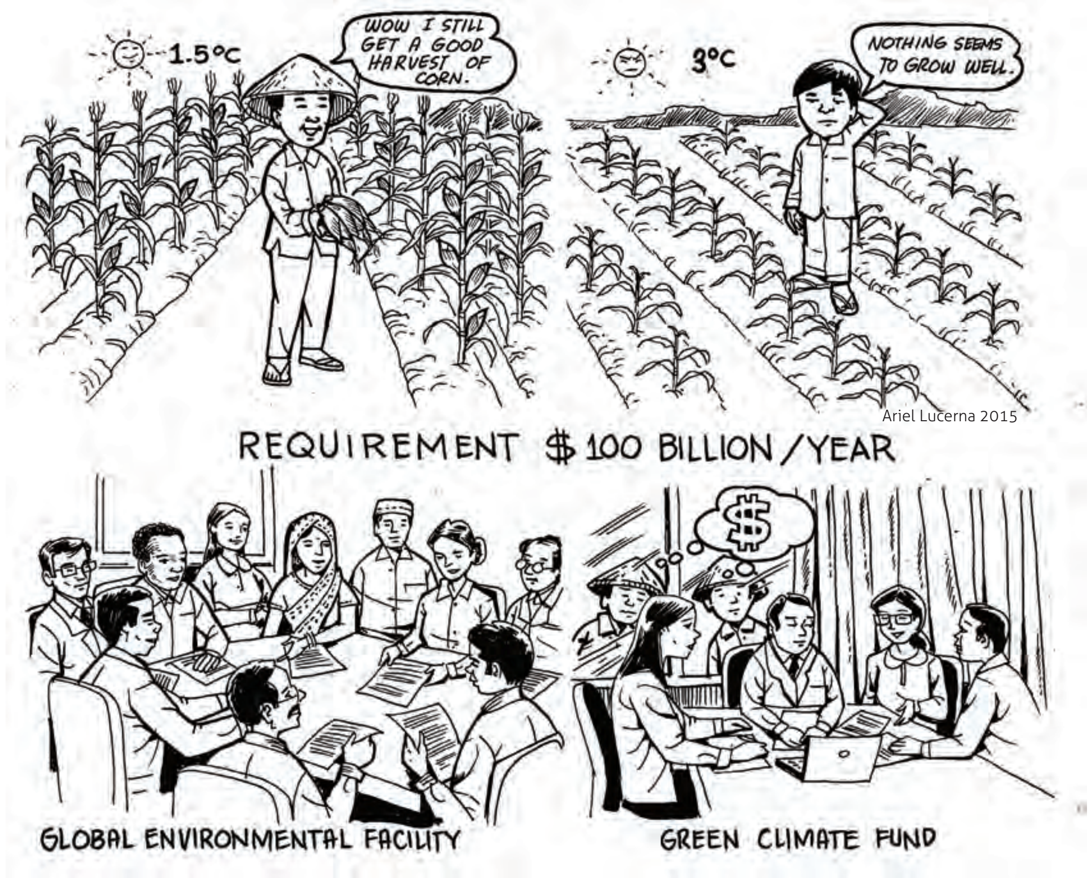

The Paris Climate Agreement: what it means for food and farming

Key messages

- The Paris Agreement opens the door for more adaptation and mitigation in the agriculture sector
- Countries must take urgent action to reduce emissions from the agriculture sector in order to limit global warming below 2 degrees C.
- Funding and political will are needed to support developing countries to implement their plans to combat and adapt to climate change in the agriculture sector
- The global agriculture community, including CGIAR, must step up and engage in key UNFCCC processes between now and 2020 to drive action and innovation on issues related to agriculture

In December 2015, parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed on a global climate change agreement to replace the nearly expired Kyoto

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This article was taken from a longer article entitled *The Paris Climate Agreement: what it means for food and farming* by Vanessa Meadu, Isabelle Coche, Sonja Vermeulen, and Anette Engelund Friis which was released in December 2015. Refer to the source box towards the end of this article for complete reference to the original article.

Protocol. The Paris Agreement aims to limit the increase in global average temperatures to "well below two degrees C" and to pursue efforts to limit it to 1.5 degrees C, and will come into force in 2020. Food security and agriculture are not overlooked in the Paris Agreement. In fact, the collective outcomes of COP21 offer many opportunities for action on food and farming—to be seized by the global agriculture community.

Food security, food production, human rights, gender, ecosystems and biodiversity are explicit in the Agreement

- The preamble of the final agreement text makes specific reference to "the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change".
- The preamble also refers to human rights, gender, ecosystems and biodiversity, all issues that are central to agriculture. The preamble also "recogniz[es] the importance of the conservation and enhancement, as appropriate of sinks and reservoirs of greenhouse gases referred to in the convention" which makes mitigation in agriculture possible.
- Article 2.1 of the agreement outlines its "aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty". This includes actions for "increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production".

The ambitious 1.5 degree C target offers some hope for farmers and food security

- The Paris Agreement aims to limit global temperatures "well below" two degrees C, and pursue a 1.5 degree target. As outlined by Campbell (2015), the debate between a 1.5 or two degree C target means different future scenarios for agriculture.
- For example, staple crops maize and wheat both show a trend towards greater yield losses at two degrees C than 1.5 degrees C.
- If global warming can be limited to 1.5 degrees, this will also produce fewer climate extremes than a two degree C temperature rise. This is good news for farmers in the tropics, as they will be on the frontline of heatwaves, droughts, floods and cyclones.

On the whole, country commitments to reducing emissions will not limit global temperature rise to two degrees

- The mitigation contributions outlined in the INDCs currently fall short of what is needed to deliver on the Paris Agreement. The decision text of the Paris Agreement "notes with concern that the estimated aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the intended nationally determined contributions do not fall within least-cost 2 ˚C scenarios but rather lead to a projected level of 55 gigatonnes in 2030" (para 17).
- The text also notes that "much greater emission reduction efforts will be required" than what have already been put forward.

A 1.5 degree C target demands urgent mitigation in agriculture sector

- As noted by Campbell (2015) a 1.5 degree C target will require even more mitigation effort from the agriculture sector than a two-degree target. But even with a two degree C target, by 2050 we will likely run out of viable options for reducing emissions from the industrial, transport and energy sectors.
- Reducing emissions from agriculture will be imperative as it will be impossible to stay within either a 1.5 or two degree C target if agriculture does not contribute to emissions reductions.

Countries want to take action on adapting agriculture and reducing emissions from farming—but funds are not yet there

- A comprehensive analysis of agriculture in national climate plans by Richards et al (2015) reveals that agriculture is discussed in 80% of Intended Nationally Determined Contributions (INDCs).
- Considerable finance is needed for agricultural adaptation and mitigation by Least Developed Countries (LDCs)—in the order of USD 5 billion annually (Richards et al. 2015). This sum, which may be an underestimate due to the small sample, is much higher than current commitments to climate funds for agriculture and is at least ten percent more per year than multilateral climate funds spent on agricultural projects in the last decade.
- It remains unclear exactly how developing countries will be supported to implement their INDCs.
- The Paris Agreement commits developed countries to set a new collective financing goal of at least USD 100 billion per year, "taking into account the needs and priorities of developing countries" (para 54), but does not include binding requirements on financial contributions by individual countries.
- The Green Climate Fund (GCF) and the Global Environment Facility (GEF) are entrusted to administer support for developing countries, particularly to implement national adaptation plans and actions
- It remains to be seen if there is sufficient political will to move from business as usual to necessary action, and if countries will channel the much needed funding to where it is needed.

There is no binding requirement for countries to implement their intended contributions, but much emphasis on cooperation and public investment

- The decision text of the Paris Agreement does not put pressure on countries to implement the INDCs, but rather encourages countries to develop and share them, and collectively take stock of progress in 2018 (para 20), particularly in relation to progress against the 1.5 degree C target (para 21).
- The INDCs cover adaptation as well as mitigation, and the Paris Agreement recognises that different countries will need different balances to meet poverty reduction and development goals.
- Countries will submit new INDCs every five years, and are encouraged to enhance action ahead of 2020. "Voluntary cooperation" between countries, including through technology transfer and capacity building, is a major theme of the Agreement.

- The Agreement emphasises the need for all countries to support science and research, "strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision- making." (Article 7).

Agriculture on SBSTA agenda in 2016

Issues related to agriculture are being discussed in a slow-moving parallel process under the Subsidiary Body for Scientific and Technological Advice (SBSTA), a process initiated in 2014

- Now is the time for countries and observers to prepare their submissions on agriculture to SBSTA. In SBSTA discussions held in parallel to COP21, discussions were on issues relating to agriculture. The resulting SBSTA conclusion notes the two agricultural workshops that took place in June 2015, and the two that are scheduled for June 2016, and decides to discuss the workshop reports at its upcoming sessions in May and November 2016.
- Countries and observers to the UNFCCC have until 9 March 2016 to make submissions on the identification of adaptation measures, and identification and assessment of agricultural practices and technologies to enhance productivity in a sustainable manner.
- The SBSTA will work on a report to be presented at its November 2016 meeting, which will form the basis for a decision on agriculture, for example a possible work programme, at the SBSTA 45 in Morocco.

Next steps: 2016-2020

The Paris Agreement opens the door to further work on agriculture between now and 2020, when the agreement takes hold. This is the chance for the global agriculture community, including CGIAR, to step up and drive action:

- Support countries to implement INDCs in agriculture and food systems, via robust technical and institutional options, prioritization and metrics, and approaches for reaching scale. This includes helping Parties 'take stock' of progress on limiting emissions from all sources in 2018.
- Engage with the adaptation committee and LDC expert group to ensure modalities to recognize adaptation efforts can recognize adaptation in agriculture.
- Engage with the Paris Committee on capacity building, which will look at critical gaps and areas for action. It could also become a platform for agreeing to a common accounting methodology for agriculture, which is currently missing.
- Make submissions to the SBSTA 44 call on adaptation measures for agriculture, and assist Parties in reaching a consensus and plan for progress on agriculture.
- Contribute to the agriculture, food system, forestry and land use chapters of the IPCC's 6th Assessment Report (AR6), and assist with the IPCC's special report on agriculture and food security ahead of AR6.
- Give solid technical contributions to countries' applications to GCF and GEF to undertake actions on adaptation and mitigation in agriculture.
- Facilitate dialogue to coordinate action across sectors, particularly between forestry and agriculture and across the food-energy-water nexus, including biofuels.
- Bring agriculture into key UNFCCC forums, including the technical process on adaptation and the Lima work programme on gender.
- Establish partnership mechanisms that countries can invest in for equitable and efficient technology transfer and capacity building.
- Invest in public-private-civil-society initiatives linked to the UNFCCC, such as the 4/1000 Initiative.
- Act as a scientific partner to non-state actors who wish to implement or scale up climate-smart agriculture. For example, CGIAR will help develop metrics and track progress of the World Business Council on Sustainable Development's work on climate-smart agriculture.
- Support countries in preparation of the next round of INDCs and their low greenhouse gas emission development strategies due by 2020 – ensuring strong agricultural components in both.

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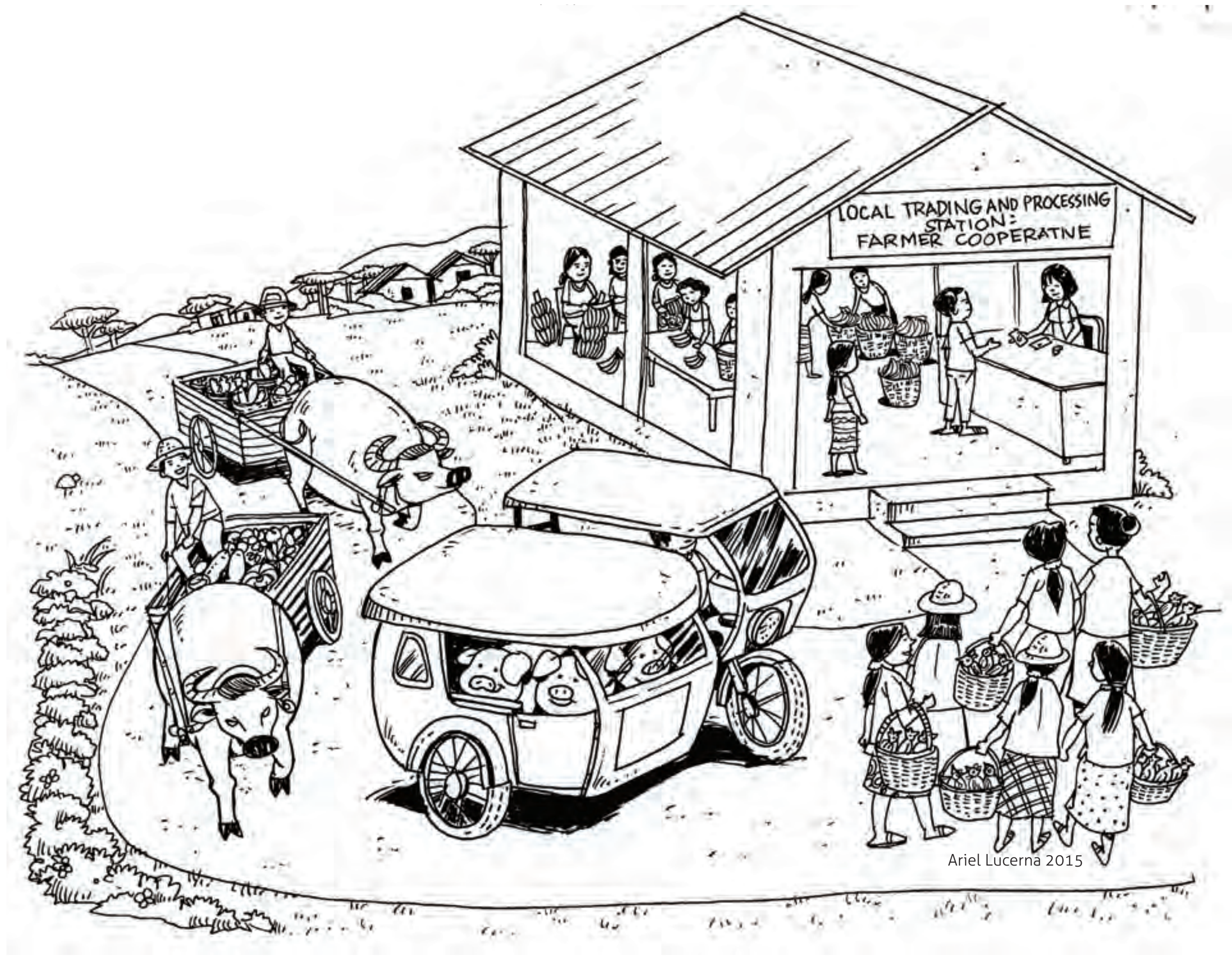

Sustainable food systems and health: The convenient truth of addressing climate change while promoting health

Feeding the world sustainably and promoting good nutrition and health

More than half of the world's 7 billion people is affected by a form of malnutrition. Despite the abundance of food supplies, there are still 795 million persons that go hungry every day (FAO, IFAD, WFP 2015). This affects their ability to work, it negatively impacts the development of their children, exposes them to illness and leads to premature deaths. Approximately 24 percent of children under five years of age are stunted (UNICEF, WHO World Bank 2015). The health of two billion people is compromised by nutrient deficiencies and 1.9 billion adults are overweight or obese (WHO 2015).

This article was adapted from a longer article entitled *Sustainable food systems and health: The convenient truth of addressing climate change while promoting health* written by Cristina Tirado, UCLA as background information for the side event organized by IUNS, FAO, UNSCN and WHO at COP21, in 7 December 2015. Refer to the source box for a complete reference to the original article.

Climate change has a negative impact on food and nutrition security and the health of millions of vulnerable people, particularly poor women and children. According to the Intergovernmental Panel of Climate Change (IPCC), if current trends continue, it is estimated that an additional 1-3 billion people will be affected by water scarcity and 200-600 million will suffer from hunger by 2080 particularly in sub-Saharan African countries.
The global food system will be further challenged over the coming decades with increases in the human population, changes in diet, climate change and greater demands on energy and water resources (Godfray et al. 2010). Between now and 2050, the world's population will increase by one-third and most of the additional 2 billion people will live in developing countries. Rapidly urbanizing areas in sub-Saharan Africa and South Asia could become potential food insecurity hotspots (FAO 2009). Changes in dietary patterns towards more production and consumption of meat and animal products present a set of complex challenges for climate change mitigation, for agriculture, for health and for achieving food and nutrition security (FAO 2009; Tirado et al. 2013; Tilman and Clark 2014). Meat and animal products provide important sources of proteins, minerals and vitamins but overconsumption is associated with an increased risk of noncommunicable diseases (NCDs) such as heart disease, type-2 diabetes and certain types of cancer (Bouvard et al. 2015; Wellesley, Happer and Froggatt 2015).

Projections show that feeding a world population of 9 billion people in 2050 would require raising overall food production by some 60% (FAO 2012). High food output achieved in the past has placed great stress on natural resources. The agriculture sector specifically is a major source of greenhouse gas (GHG) emissions. Agriculture, forestry and associated land use and land use change contribute to 20 to 30 percent of the total anthropogenic GHG emissions (Tubiello et al. 2014; 2015). The expansion of livestock and biofuel sectors plays a major role in deforestation and land degradation and contributes to climate change. Other GHG emissions stem from fossil fuel use in the field as well as from across the whole food system continuum, such as food transport, storage, cold chains, processing, and food loss and waste. Furthermore, globally about one-third of food produced for human consumption per year is lost or wasted. (Gustavsson et al. 2011; Vermeulen et al. 2012).

Although health is one of the three main aims of the original UN Framework Convention for Climate Change (UNFCCC) (article 1) in 1992, on equal level with natural environment and economy, it has been neglected by the climate discussions ever since. Safeguarding food production is part of the ultimate objective of the UNFCCC (article 2), yet health, food security and nutrition considerations are weak (food security and health) or absent (nutrition) within the current narrative of the UNFCCC Ad Hoc Working Group on the Durban Platform for Enhanced Action.

The challenge today is to sustainably improve nutrition and health through implementation of coherent policies and better coordinated actions across all relevant sectors, strengthening, preserving and recovering healthy and sustainable food systems (FAO, WHO 2014).

Opportunities to address these challenges

The Rome Declaration on Nutrition, adopted by Member States at the FAO, WHO Second International Conference on Nutrition (ICN2) recognizes the need to address the impacts of climate change and other environmental factors on food security and nutrition, in particular on the quantity, quality and diversity of food produced, taking appropriate action to tackle negative effects (FAO, WHO 2014).

The ICN2 commitments offer a unique opportunity to address the impacts of climate on nutrition and to promote the co-benefits of sustainable and healthy dietary patterns to health and the environment.

Sustainable Development Goal 2 (SDG2) to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" commits Member States to end hunger and to achieve food security and to end all forms of malnutrition as a matter of priority. SDG12 requests Member States to ensure sustainable consumption and production patterns and SDG13 urges them to take urgent action to combat climate change and its impacts while acknowledging that the United Nations Framework Convention on Climate Change (UNFCCC) is the primary international, intergovernmental forum for negotiating the global response to climate change.

The mandates are identified, the commitments are made to address the impacts of climate change on health and nutrition; these commitments should now be integrated in the climate change agenda and climate funding mechanisms at national and international levels.

The ICN2 Framework for Action provides policy options and actions for sustainable food systems promoting healthy diets (FAO, WHO, 2014) including:

- To review national policies and investments and integrate nutrition objectives into food and agriculture policy, programme design and implementation, to enhance nutrition sensitive agriculture, ensure food security and enable healthy diets.
- To strengthen local food production and processing, especially by smallholder and family farmers, giving special attention to women's empowerment, while recognizing that efficient and effective trade is key to achieving nutrition objectives.
- To promote the diversification of crops including underutilized traditional crops, more production of fruits and vegetables, and appropriate production of animal-source products as needed, applying sustainable food production and natural resource management practices.
- To improve storage, preservation, transport and distribution technologies and infrastructure to reduce seasonal food insecurity, food and nutrient loss and waste.
- To establish and strengthen institutions, policies, programs and services to enhance the resilience of the food supply in crisis-prone areas, including areas affected by climate change.

Key messages

Sustainable and healthy diets can contribute to both a reduction in GHG emissions and improved public health and nutritional outcomes. It is necessary to reshape food access and consumption patterns to ensure nutrient requirements of all age groups and all groups with special nutrition needs are met and to foster healthy and sustainable eating patterns worldwide. The IPCC AR5 report highlighted the opportunities to achieve co-benefits from actions that reduce emissions and at the same time improve health by shifting consumption away from animal products, especially from ruminant sources, in high meat consumption societies, toward less emission intensive healthy diets. Sustainable and healthy diets can be realized by developing a food system that embraces fundamental values such as: establishing a culture of healthy living, embracing equitable solutions, supporting universal food security; encouraging active citizenship to steward natural resources and transparency (DGAC 2015). These values need to be incorporated in the health, nutrition, food, education, agriculture, water, energy, transport and environmental sectors as well as taken into account when establishing robust and transparent private and public sector partnerships.

Enhance sustainable food systems by developing coherent public policies from production to consumption and across relevant sectors to provide year-round access to food that meets people's nutrition needs and promote safe and diversified healthy diets. Since food systems have become increasingly complex and strongly influence people's ability to consume healthy diets, coherent action and innovative food system solutions are needed to ensure access to sustainable, balanced and healthy diets for all. Special attention needs to be paid to the promotion of breastfeeding: it provides safe and nutritious food all year-round for infants and young children. Breastmilk is the ideal food under all circumstances but can be particularly beneficial in times of emergencies due to its availability, affordability and safety. Breastmilk is a natural and renewable food that involves no packaging, transportation or fuel to prepare and therefore contributes to environmental sustainability (UNICEF 2015). The ICN2 Framework for Action recommendations, adopted by the FAO and WHO member states, propose policy options and actions to be implemented. Agreement on shared principles of sustainability in promoting healthy diets is needed (FAO, WHO 2014).

Promote sustainable production and consumption in food systems and agriculture. This concept refers to the integrated implementation of sustainable patterns of food production and consumption, respecting the carrying capacities of natural ecosystems. It requires consideration of all the aspects and phases in the life of a product, from production to consumption, and includes such issues as sustainable lifestyles, sustainable diets, food losses and food waste management and recycling, voluntary sustainability standards, and environmentally-friendly behaviours and methods that minimize adverse impacts on the environment and do not jeopardize the needs of present and future generations (FAO,UNEP 2014). A practical way to realize this concept is to upscale the use and entrench into relevant policies, Ecosystems Based Adaptation approaches (EBA) to food production, and link these to sustainable value chain processes such as clean energy powered food processing in a continuum (UNEP 2012).

Nutrition-sensitive climate adaptation and mitigation has many co-benefits for both health and the environment. Address food and nutrition security in the National Adaptation Plans (NAPs) and Nationally Appropriate Mitigation Action Plans (NAMAS). A combination of nutrition-sensitive, climate-smart strategies and technological development, nutrition-smart investments in the agriculture and food sectors but also in social protection, education and community-based disaster risk reduction areas can contribute to ensure food and nutrition security in a changing climate (Tirado et al. 2013). Policy coherence needs to be ensured through institutional and cross-sectoral collaboration.

Adopt a multi-sectoral approach and good governance. Reaching and sustaining food and nutrition security in a changing climate requires a multi-sectoral food system approach involving nutrition, agriculture, health, trade, education, water supply and sanitation and social protection, as well as taking into account cross-cutting issues like gender equality, governance, and state fragility.

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By: Cristina Tirado, UCLA as background information for the side event organized by IUNS, FAO, UNSCN and WHO at COP21
December 7, 2015

Climate change, food security and small-scale producers

Farmers, businesses and governments around the world report growing impacts of climate change on agricultural production and food security, and are trying to find ways to adapt to change. The chance to measure these real-life experiences and efforts against new science is extremely useful, but rare. Released during 2013 and 2014, the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) offers the first opportunity since 2007 for us to appraise the global scientific consensus on climate change drivers, impacts, adaptation and mitigation.

This briefing note offers an overview of what AR5 has to say on the impacts of climate change on food and farming—particularly the food and farming of the half a billion small-scale croppers, livestock keepers and fishers who are most immediately dependent on agricultural systems for their livelihoods. It is based on two related sources within the output of Working Group 2 under AR5: (a) Chapter 7 on Food Security and Food Production Systems and (b) the Summary for Policy Makers. The IPCC's Working Group 2 is tasked with assessing the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adaptation.

This article was drawn from previously published materials entitled *Climate change, food security and small-scale producers* by Sonja Vermeulen. Refer to the source box towards the end of this article for a complete reference to the original article.

The briefing note starts with where we are as concerns climate change in the 2010s, then looks ahead 15 years to impacts and adaptation in the 2030s, before touching finally on the 2050s and beyond.

2010s: How climate change is affecting today's food security

Until recently, the impacts of climate change have been understood largely as a problem for of future, that will benefit from advance planning. A key finding of AR5 is that climate change impacts on food security are happening now. Moreover, these impacts are not evenly distributed — tropical areas that are most exposed to increasing climate risks are also home to a large proportion of the world's food-insecure people.

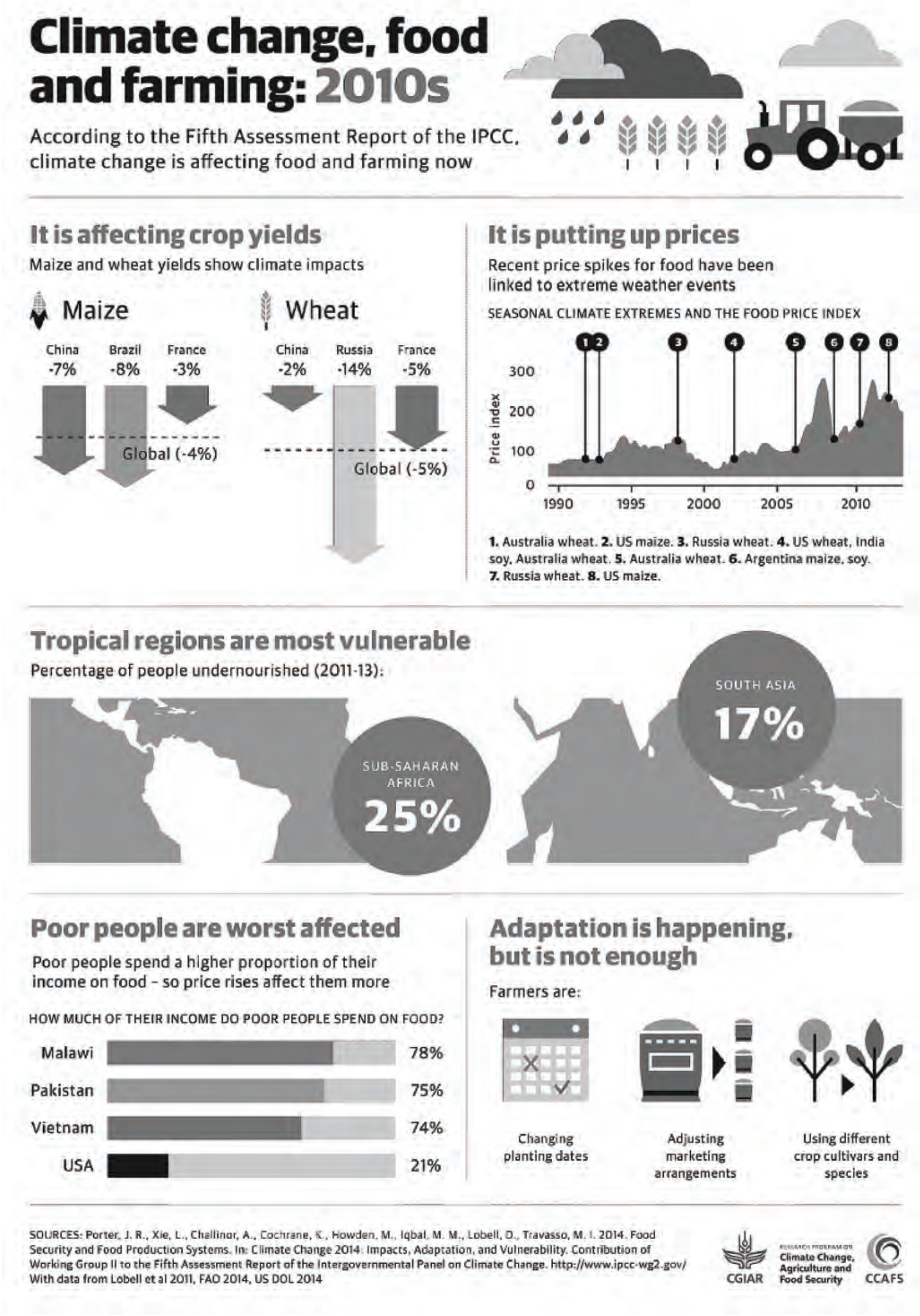
Climate change has impacts on all aspects of food security. Evidence is now clear that climate change is affecting food security for everyone, particularly for poor people. AR5 does not quantify the overall impact of climate change on current food security, as the task is too difficult. Food security at national and individual levels depends fundamentally on how much food is produced, but also on distribution, affordability and a host of additional factors, such as culture and health. Climate change affects availability of food, access to food, utilization of food and stability of food supplies over time.

Impacts of climate change on crop yields are already evident across several regions of the world, as AR5 reports with high confidence. Although positive impacts are observed in some high latitude areas such as northeast China and the UK, globally negative impacts are more common. There is medium confidence that climate change has a negative impact on net global yields of maize and wheat. By contrast, for rice and soybeans, impacts of climate change on current global yields are small.

Climate change is affecting the current abundance and distribution of freshwater and marine fish harvests. Globally, warmer water species have increased as a relative contribution to catches by at higher latitudes. For example, in the well-studied northeast Atlantic, abundance of key species is shifting polewards, associated with rapid rises in sea temperatures in recent decades. Meanwhile subtropical species have decreased. These changes have negative implications for small-scale coastal fisheries in tropical countries, which employ the majority of people working in capture fisheries. Their food security is negatively impacted via smaller catches and lower incomes.

Recent price spikes for food have been related to climatic extremes in major production areas. Several periods of rapid increases in international food prices have occurred since 2007, affecting consumers who are linked into international food markets. Price increases result from multiple factors, including competing demand among human food, animal feed and biofuels, but it is evident price spikes often follow extreme climate events, which have become more likely as a result of climate trends. Poor consumers spend a greater proportion of their incomes on food, and thus suffer the greatest negative impacts of food price rises.

Climate change has impacts on the nutritional quality and safety of food. Cereals grown in elevated carbon dioxide show a decrease in protein and micronutrients, but ozone has the opposite effect. Thus, it is clear that climate trends directly affect nutrition, but there is not yet any confidence in predicting nutritional outcomes for consumers. The key food safety issue for plant-derived foods with climate change is mycotoxins (poisons from fungal infections, for example in stored maize). In temperate and cooler tropical regions, mycotoxins may increase



with rising temperatures, but in the hotter tropics mycotoxins may be eliminated as temperature surpasses thresholds for survival of the pathogen.

Tropical crops, livestock and fisheries are most affected by current climate change; regions of major exposure to climate change coincide with high prevalence of poverty and food insecurity. Negative impacts of climate change on crop yields and on fisheries are strongest in tropical regions. Livestock in tropical regions are possibly at greater risk from climate change due to sensitivity to temperature, water and feed availability. These tropical areas of high exposure to climate change coincide with areas of current low food security. The largest numbers of food-insecure people are in South Asia, while the largest proportion of food insecure people is in sub-Saharan Africa, where 27% of people were undernourished in 2010-2012. Food security and local economies are expected to be at most risk from climate change in sub-Saharan Africa, South Asia, Central America, northeast Brazil and parts of the Andean region.

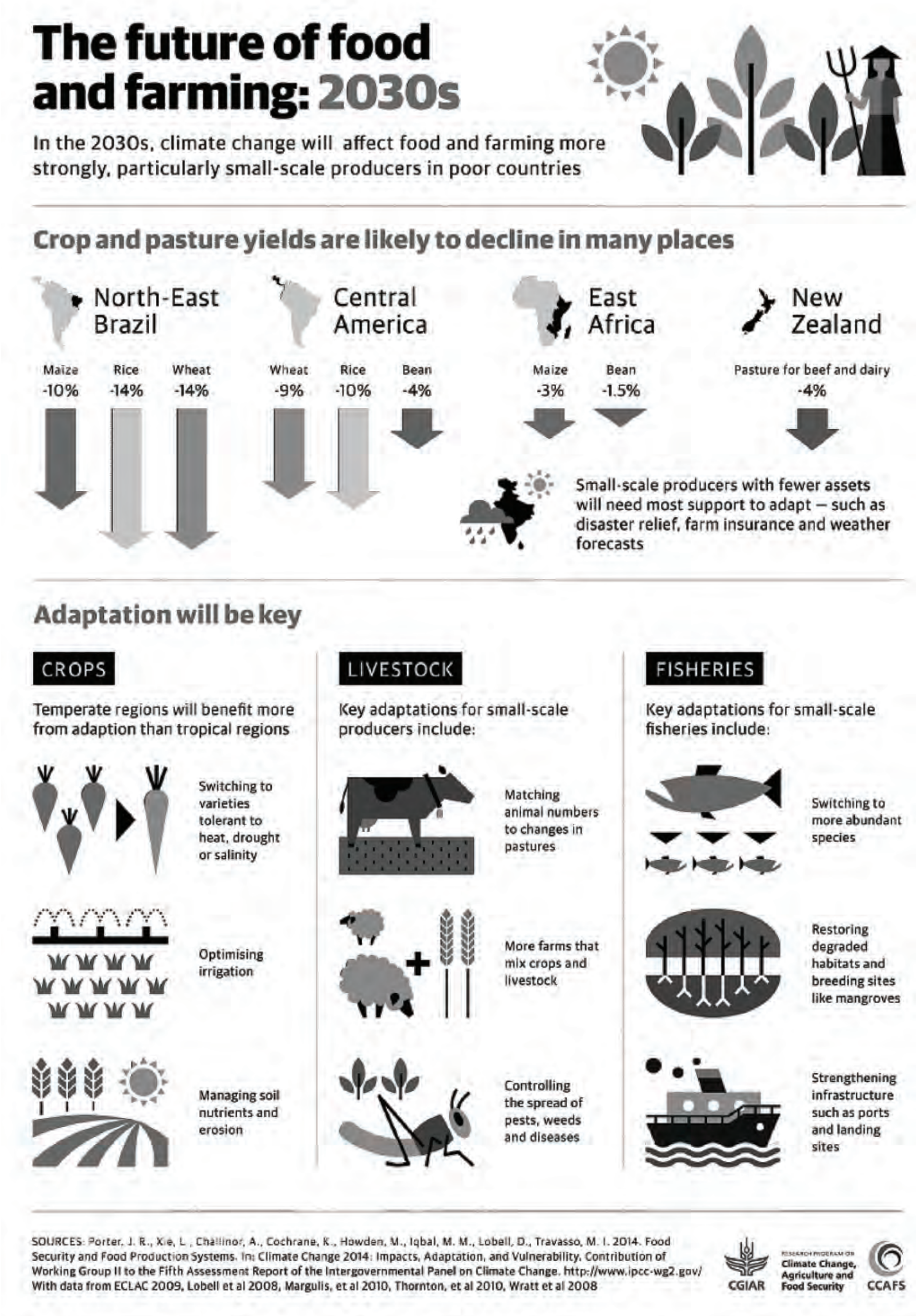
Greater exposure to climate risks increases the vulnerability of food insecure individuals and households. Increases in climate extremes, such as floods, droughts or heatwaves, exacerbate the vulnerability of all food insecure people, AR5 reports with high confidence. Many small-scale producers (farmers, livestock keepers and fishers) buy more food than they sell agricultural produce, meaning that they are negatively impacted by food price rises. Small-scale producers tend to respond to climate risks by increasing off-farm employment where possible, and reducing consumption. Reductions in food consumption include switching to more calorie-dense but nutrient-poor foods. Reductions in consumption of non-food items such as health and education, raise the likelihood of long-term negative outcomes on wellbeing and food security.

Farmers are already adapting to climate change. Observed adaptation include shifts in planting dates, use of different crop cultivars and species, and adjustments to marketing arrangements. Adaptations may need substantial technology or knowledge to implement; for example early sowing is enabled by improvements in machinery and by the use of techniques such as dry sowing and seed priming. Another adaptation with proven efficacy in specific circumstances is provision of multi-scale climate forecasts to inform crop risk management. Indigenous knowledge (as opposed to scientific knowledge) is important to both climate risk management and food security but its contribution is sometimes limited by policies and regulations. Climate change may be diminishing reliance on indigenous knowledge in some places, as climatic conditions move beyond recent human experience.

2030s: Options for adaptation as climate change advances

Looking forward to the 2030s—a realistic planning horizon for many farmers, governments and businesses in the food sector—AR5 anticipates increasing impacts of climate change on agriculture and food. Adaptation becomes increasingly important. Chapter 7 of WG2 defines adaptation as "reductions in risk and vulnerability through the actions of adjusting practices, processes and capital", and notes that adaptation is as much about institutional change as technical change. The many adaptations that farming systems can undertake in the next couple of decades need to respond not only to climate risks, but to other pressures on food such as growing populations and increasing per capita consumption. Small-scale producers will be hardest hit by climate change and will need considerable support to adapt.

Climate risks will continue to multiply threats to poor producers in rural areas. Rural areas will continue to be home to the majority of poor people for at least the next few decades, even as population growth is higher in urban areas. Livelihoods in rural areas will continue to be in



large part dependent on agriculture, while climate risks to agriculture are expected to increase. Greater exposure to climate risk, without insurance, leads small-scale producers to: (1) prefer low-risk, low-return subsistence crops over high-risk, high-return cash crops (2) be less likely to apply fertilizer or other purchased inputs and (3) defer adoption of new technologies. Together these responses will increasingly reduce both current and future farm profits, and thus increase food insecurity among already poor rural populations.

Overall, decreases in crop yields are more likely than increases, including in temperate regions, and even with only moderate warming. With or without adaptation, negative climate-related decreases in yields become likely from the 2030s, with changes of 0 to -2% per decade in median yield. Without adaptation, local temperature increases of more than 1°C above preindustrial temperatures are expected to reduce yields of wheat, rice and maize in both tropical and temperate regions. Projected yield decreases are larger in tropical than in temperate regions. South Asia and Southern Africa are two regions that without adaptation might undergo greatest yield declines among important crops. Some specific locations may benefit from moderate warming, particularly in northern temperate countries.

Benefits of adaptations in crop management are roughly 15 to 18% of current yields for major cereals. Projected benefits of adaptation are greater for crops in temperate than in tropical regions. Different adaptation options offer different benefits to yields: switching varieties gives a median benefit of 23%, compared to 3% for optimizing irrigation or 1% for increasing fertilizer use. The benefits of switching to new varieties suggest that gene banks and breeding of heat-tolerant and drought tolerant varieties are priorities for adaptation investments. Other adaptations with demonstrable benefits include water harvesting, storage and efficiency measures, and diversification of on-farm and off-farm activities to reduce exposure to climate risks.

Increasing climate change impacts on livestock include quality and quantity of feed, and heat and water stress. Pasture provides more than half of animal feed globally, but estimating impacts of climate change on pastures is difficult due to the complexity of grassland ecosystems. Temperature is another important limiting factor for livestock. Highly productive animals have higher metabolic heat production and less tolerance of high ambient temperatures. Heat stress has impacts on both productivity and animal welfare. Climate change will also alter the water resources available for livestock.

Multiple adaptations are possible in livestock production, and these largely build on long-term experience in managing climate risks. Key adaptations for small-scale producers include matching stocking rates with pasture production, switching to more suitable breeds or species, managing the age structure of herds differently, adjusting water point usage to altered patterns of forage availability, managing diet quality, more effective use of silage, pasture rotation, fire management, changing the balance of cropping and livestock in farming systems, migratory pastoralist activities, and interventions to monitor and manage the spread of pests, weeds and diseases. Combinations of adaptation actions will tend to work better than single interventions.

Changes in water quantity and quality will result in significant changes in fisheries and aquaculture. Changing precipitation, affected groundwater and river flows, sea level rise, melting glaciers and ocean acidification are all expected to have consequences for capture fisheries and aquaculture. For example, mollusks, which comprise 24% of global aquaculture production, will be negatively affected by the impacts of ocean acidification on shell formation. Extreme climatic events are anticipated to have major impacts on low altitude coastal aquaculture, while marine fisheries will suffer more lost working days due to bad weather.

Adaptation of fisheries and aquaculture requires both institutional and technical changes. Key adaptations for aquaculture include improved feeds, breeding for heat tolerance and acid-tolerance, improved site selection, and water use planning that is integrated with other sectors. For small-scale fisheries, key interventions might include occupational flexibility, switching target species, restoring degraded habitats, developing early warning systems, strengthening infrastructure such as ports and landing sites, establishing insurance schemes, and improving responsiveness to rapid change in fisheries governance.

2050s and beyond: Longer-term outlook for food security and agricultural livelihoods

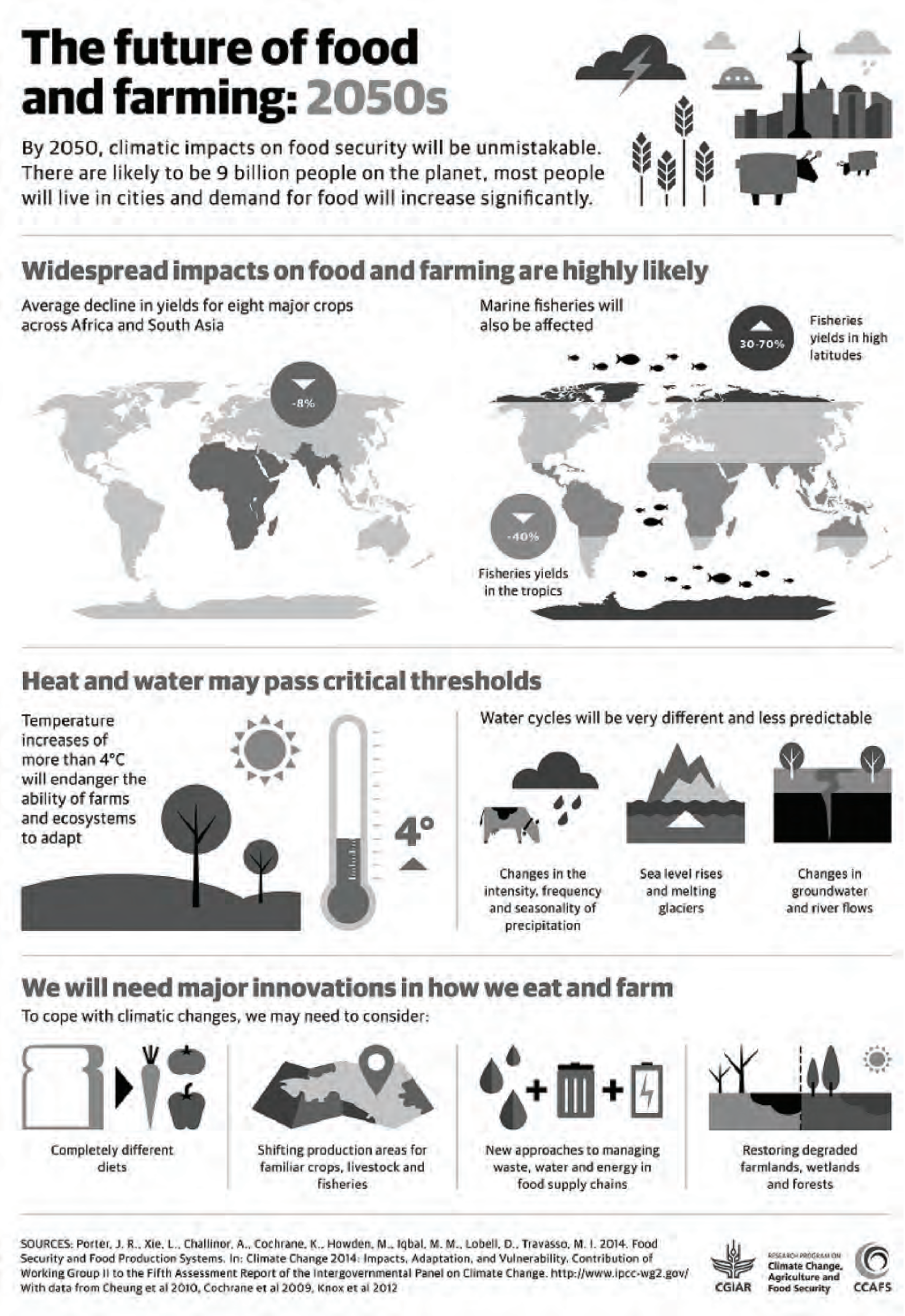
By the 2050s, global population will have risen to around 9 billion people and societies will have undergone further shifts in urbanization, aging, diets and wealth distribution. AR5 makes it clear that it is from the 2050s onwards that climatic impacts on food security will be unmistakable, particularly in the context of societal change and increasing demand for food. Tropical regions will experience the greatest negative effects—and small-scale crop, livestock and fisheries producers will face the greatest challenges of adaptation.

International food price rises due to climate change are very likely by 2050. Taking multiple climate impact studies into account, AR5 concludes that it is very likely that changes in temperature and precipitation, ignoring the effects of elevated carbon dioxide, will lead to food price increases of 3–84% by 2050. Furthermore, crop demand is expected to rise roughly 14% per decade until 2050 due to rising populations and changing diets and demographic patterns, placing pressure on prices of all foods.

Agriculture in tropical countries will continue to be most consistently and negatively affected by climate change. A synthesis of projections of crop yields across regions estimates an average decline by 2050 of 8% for Africa and South Asia for all crops. Wheat, maize, sorghum, and millets will be worse affected than rice, cassava, and sugarcane. Also by 2050, at least half the cropping area of most African countries will have climates that are outside current experience in the country. In the Indo-Gangetic Plains, half of the wheat-growing area, one of the world's great breadbaskets, may be under heatstress by the 2050s. In general, the length of the growing season and suitability for crops is likely to decline in all tropical farming systems where moisture availability or extreme heat rather than frost is the limiting factor.

For local warming of 4°C or more, there will be limits to adaptation and significant risks to food security. For crops, which are far better studied than livestock and fisheries, recent studies confirm several findings reported in AR4, including that all crop species and varieties are likely to experience yield declines with local warming of more than 3°C, even with benefits of higher rainfall and carbon dioxide. For local warming of more than 4°C above pre-industrial levels, the ability of farming systems and natural ecosystems to adapt is severely compromised, with or without adaptation, posing major risks to food security.

Tropical fisheries yields may decrease by up to 40% by the 2050s, and small-scale fisheries will be hit hardest. Projections based on continued high levels of emissions (SRES A1B scenario) suggest a decrease of up to 40% in fisheries yields in the tropics by 2055, compared to yield gains of 30–70% at high latitudes. Research also suggests that the flexibility of large-scale commercial fisheries, for



example in terms of their spatial range, means that they will be better able to adapt and take advantage of changing fisheries.

Uncertainties around future vulnerability of human and natural systems tend to be even larger than uncertainties in regional climate projections. To date, policy-makers and scientists have weak understanding of the socio-economic factors that determine how vulnerable people, farming systems and ecosystems are to climate change. Improving the accuracy of downscaled climate projections to sub-national levels will help adaptation actions, but tacking vulnerability may be even more important. Factors identified by the AR5 summary for policy makers as influencing vulnerability include "wealth and its distribution across society, patterns of aging, access to technology and information, labour force participation, the quality of adaptive responses, societal values, and mechanisms and institutions to resolve conflicts".

Interactions between water resources and agriculture will be increasingly important as climate changes. AR5 notes that changes in precipitation will be important for the future of agriculture at sub-national levels, but that projections at local scales are uncertain. Changes in intensity, frequency and seasonality of precipitation, alongside sea level rise and glacier melting, will affect groundwater and river flows. Impacts on fisheries, aquaculture and livestock as well as crops are anticipated, and increases in demand for water will need to be offset against demand from other sectors. For example, one study estimates a 20% increase in demand for water by cattle in Kgatleng District, Botswana by 2050.

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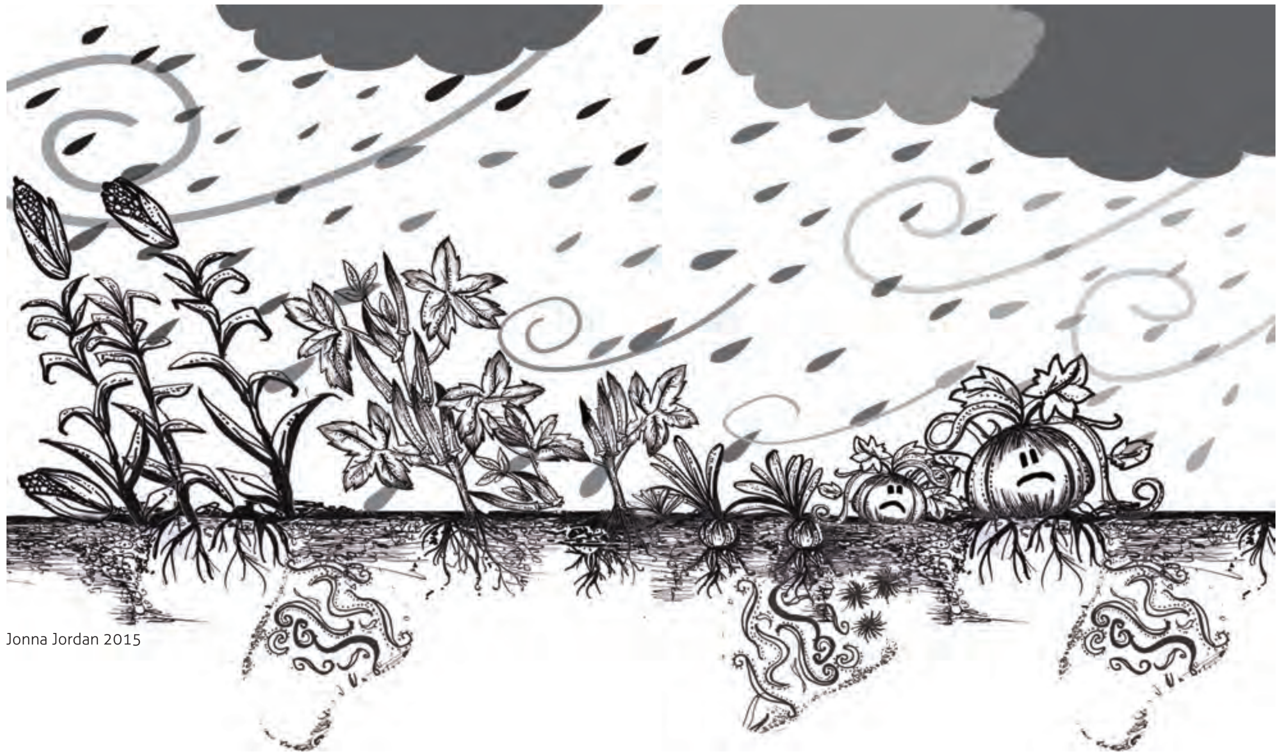

Jonna Jordan 2015

Nutrition insecurity:
A major consequence of climate change

Climate change affects food and nutrition security and further undermines current efforts to reduce hunger and protect and promote nutrition (Easterling et al. 2007; Confalonieri et al. 2007; Costelo et al. 2009; Nelson et al. 2009; FAO, 2008a; UNICEF, 2007; WHO, 2008; Parry et al. 2009; UNSCN, 2010). Additionally, undernutrition in turn undermines the resilience to shocks and the coping mechanisms of vulnerable populations, lessening their capacities to resist and adapt to the consequences of climate change.

Climate change will increase the risk of hunger and undernutrition over the next few decades and challenge the realization of the human rights for health and adequate food (UN, 2010; Caesens et al. 2009). Climate change will affect nutrition through different causal pathways that impact food security, sanitation, water and food safety, health, maternal and child health care practices and many socioeconomic factors (Easterling et al. 2007; Confalonieri et al. 2007; Costelo et al. 2009; Nelson et al. 2009; FAO, 2008a; UNICEF, 2007; WHO, 2008; Parry et al. 2009; UNSCN, 2010).

With a likely change in the patterns of climate-related extreme events, such as heat waves, droughts, storms, heavy precipitation and floods (Meehl et al. 2007) and increased risks of disasters (UNISDR, 2008), vulnerable communities and households will suffer serious setbacks

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in terms of food and nutrition security (Easterling et al. 2007; FAO, 2008a; Tirado et al. 2010a). The Intergovernmental Panel of Climate Change (IPCC) fourth assessment report (AR4) concluded that undernutrition linked to extreme climatic events may be one of the most important consequences of climate change due to the very large numbers of people that may be affected (Confalonieri et al. 2007).

Climate change negatively affects food availability, conservation, access and utilization and exacerbates socioeconomic risks and vulnerabilities. Climate change is expected to further reduce food productivity and to make production even more erratic in regions where agricultural productivity is already low (Parry et al. 2009). With local production declining and probable disruptions caused by climate hazards, income generating opportunities and purchasing power will decrease for vulnerable populations. At the same time, decreases in production could lead to price increases for staple crops of 25 to 150% by 2060 (Parry et al. 2009). According to the IPCC AR4, if current trends continue, it is estimated that 200–600 million more people will suffer from hunger by 2080 (Yohe et al. 2007). Calorie availability in 2050 is likely to decline throughout the developing world resulting in an additional 24 million undernourished children, 21% more relative to a world with no climate change, almost half of which would be living in sub-Saharan Africa (Nelson et al. 2009; Parry et al. 2009).

Climate change negatively affects nutrition through its impacts on health and viceversa. Climate change has an impact on water availability and quality, sanitation systems, food safety and on waterborne, foodborne, vector-borne and other infectious diseases (Confalonieri et al. 2007; FAO 2008b; Tirado et al. 2010b) which eventually both increase nutritional needs and reduce the absorption of nutrients and their utilization by the body. The impacts of climate change on nutrition and health will further aggravate the effects of the HIV pandemic, reducing the workforce dedicated to agriculture and the food supply (UNEP and UNAIDS, 2008). This is a great concern considering that most of the populations affected by HIV depend on agriculture for their livelihoods (Gillespie and Kadiyala, 2005). Climate change will also put further strain on the already heavy workload of women with negative impacts on their ability to provide proper care to infants and young children, heightening the risk of undernutrition (CIDA 2002; Crahay et al. 2010).

The poorest and most vulnerable, including women, children and marginal communities are also at greatest risk to suffer from the potential impacts of climate change (WFP et al. 2009). This is due to their high exposure to natural hazards, their direct dependence on climate-sensitive resources, and their limited capacity to adapt to and cope with climate change impacts (WFP et al. 2009). Smallholder and subsistence farmers, pastoralists and artisanal fisherfolk in particular will suffer complex, localised impacts of climate change (Easterling et al. 2007).

Mitigation is critical to limit impact of climate change on food security and nutrition in low and middle income countries in the future. However, mitigation strategies should not increase food and nutrition insecurity.For example, biofuel production can have a negative impact on food production and nutrition (FAO, 2008a). Biofuel production requires large amounts of natural resources (arable land, water, labour,

etc.) that might thus be diverted from the cultivation of food crops (FAO, 2008a). Food availability may subsequently be reduced, leading to shortages on markets and associated food price increases (FAO, 2008a).

The realization of the right to food can be compromised both by inadequate climate change mitigation strategies (Tirado et al. 2009) and by the failure to implement these strategies (Caesens et al. 2009). Sustainable and appropriate solutions need to be urgently explored, tested and implemented for climate change mitigation strategies that do not harm food and nutrition security.

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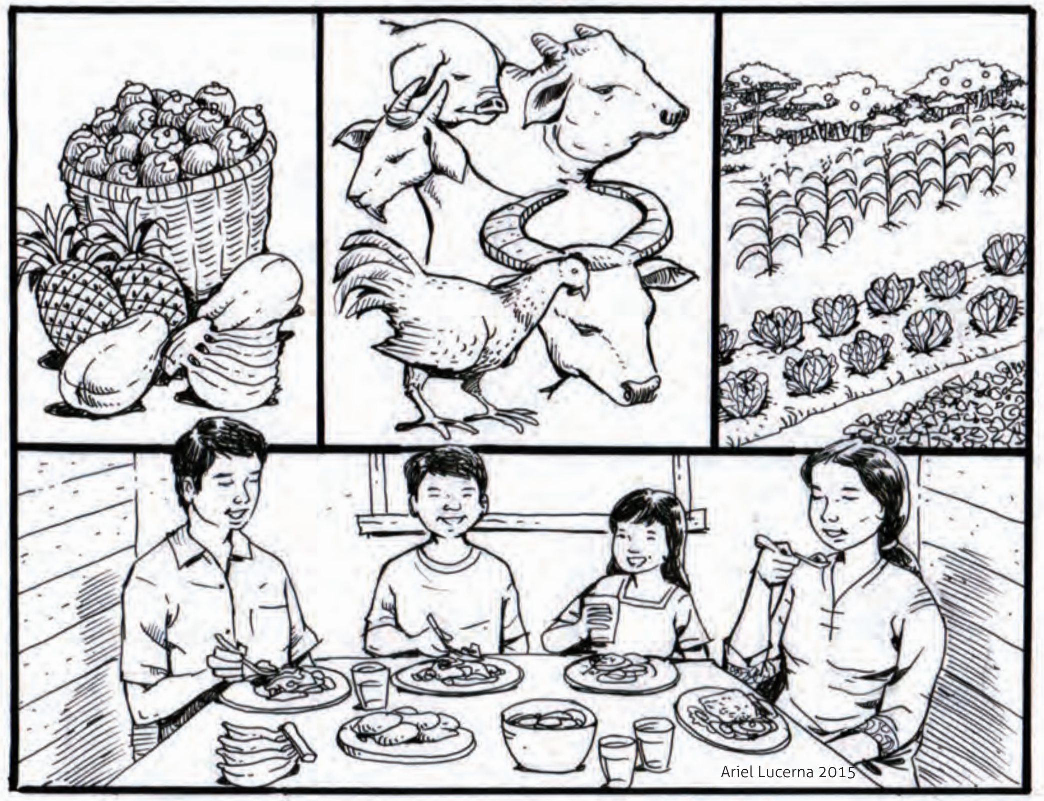

Ensuring nutritional security in a changing climate

A combination of action on climate change adaptation and mitigation supported by research and technological development can reduce the threats to food and nutrition security. A revitalized twin-track approach has been proposed to address the impacts of climate change on food and nutrition security (FAO 2008a; Tirado et al. 2010). Track one consists of direct and immediate nutrition interventions and safety nets. Track two consists of a broader multi-sectoral approach, which mainly involves sustainable and climate resilient agriculture and rural development, health and social protection schemes, risk reduction and management plans and community approaches addressing the most vulnerable among others (FAO 2008a; WFP 2009; Tirado et al. 2010).

Since the effects of climate change all are extremely location specific, international and national stakeholders should work to ensure that technical, financial, and capacity-building support reaches local communities (Nelson et al. 2009). They should promote community-based and needs-driven approaches, and encourage community participation in national planning processes.

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Adaptation: Direct nutrition interventions and multi-sectoral approaches

Direct nutrition interventions to build resilience to climate change impacts

Direct nutrition interventions can contribute to reducing vulnerability and building resilience to climate change consequences. The 2008 Lancet series on efficacious nutrition interventions and a 2009 World Bank study on the programmatic feasibility and cost-effectiveness of these interventions lead to the identification of a package of highly cost-effective interventions, concentrating on the window of opportunity for children under two years of age but including some components with broader benefits, including for maternal undernutrition (Horton et al. 2009; Bhutta et al. 2008). These high-return interventions would improve family nutrition practices and supplement foods and micronutrients provided by families, whether through market purchases or through home production (SUN 2010). These evidence-based direct interventions to prevent and treat undernutrition include:

- Promotion of good nutrition and hygiene practices, such as breastfeeding, complementary feeding for infants beyond six months of age, improved hygiene practices including handwashing, and deworming programs;
- Micronutrient supplementation for young children and their mothers (e.g. periodic Vitamin A supplements and therapeutic zinc supplements for diarrhea management);
- Provision of micronutrients through food fortification for all (e.g. salt iodization; iron fortification, etc.);
- Therapeutic feeding for malnourished children with special foods, including the prevention or treatment for moderate undernutrition and the treatment of severe undernutrition ("severe acute malnutrition") with ready-to-use therapeutic foods (RUTF) (Horton et al. 2009; SUN 2010)

Sustainable, climate-resilient and nutrition-sensitive agricultural development

Agriculture is fundamental to reducing global hunger and, along with the health and care-based approaches, is integral to improving nutrition outcomes worldwide (UNSCN 2010). Climate change instils greater urgency to find more sustainable, resilient and efficient ways of producing, trading, distributing and consuming food. Producing more food does not necessarily lead to a better access to food or to an improved nutritional status of those who need it most (Sheeran 2010). In Kenya and in the Philippines, for example, the adoption of cash crops expanded food supply and doubled the household incomes of small farmers, but 2006 studies showed that children's energy intake increased only from 4 to 7 percent, and that child undernutrition was little changed (Hawkes and Ruel 2006).

Climate-resilient agriculture should be nutrition-friendly and health-promoting, as part of a broader nutrition-sensitive agricultural development framework. Agriculture can sustainably contribute to improving dietary diversity and nutrition by supporting, among others (UNSCN 2010):

- Agricultural extension services promoting better crop diversity and biodiversity for improved nutrition;
- Integrated agro-forestry systems that reduce deforestation and promote the sustainable exploitation of nutrient-rich non-wood forest products, in particular in areas with traditional agro-forestry knowledge;
- Integrated farming systems exploiting the synergies of horticulture, aquaculture and small livestock rearing to reduce waste and expenses on agricultural inputs and increase food production diversity; and
- Improved household food production and livelihoods (i.e. diversification of household food production for self-consumption, to improve the nutritional quality of the family diet).

In addition, education, communication for development and social marketing strategies that strengthen local food systems and promote cultivation and consumption of local micronutrient-rich foods; research and development programmes for the breeding of selected crops and livestock with enhanced nutritional quality; and improved post-harvest management (food storage, transformation, handling and processing) to reduce losses in terms of quantity and nutrients content also contribute to nutrition security (UNSCN 2010).

Agricultural policies must go beyond staples and increase the availability and affordability of a diverse range of nutritious food (vegetables, fruits, animal and dairy products, small fish, under-utilized nutrient-rich indigenous foods, etc.). Agricultural policies should be pro-poor by enhancing and sustaining people's ability to procure and use the amount and variety of food required to be active and healthy. Policies must also be gender-sensitive: the majority of small-scale farmers are women, who are balancing their childcare responsibilities and farming every day. Particular attention should be given to strategies reducing workload of women taking into account the repercussions on the nutrition and care of children (Save the Children 2009). Agricultural investment in sustainable, climate-resilient, gender-sensitive and nutrition-sensitive development can contribute to reducing undernutrition among children under five years of age. The International Assessment of Agricultural Knowledge, Science and Technology for Development report (IAASTD) recommended to reverse top-down transfers of technology and replace them with bottom-up, participatory, farmer-oriented innovations (IAASTD 2008).

Access to maternal and child health care, safe water and sanitation systems and adequate, safe food

There is a need for additional investment and planning to address the new challenges posed by climate change to health related issues (WHO 2008). Maternal and child health care need to be implemented successfully and to provide near-universal coverage. Other important actions for minimizing health impacts from climate change include: strengthening of public health systems and basic clinical care systems including the availability of essential drugs; enhancing local capacities to address public health emergencies; strengthening surveillance systems of infectious disease; improving the use of early warning systems by the health sector; addressing known environmental risk factors and water-related diseases; integrating nutrition and hygiene education in interventions for the treatment of severe malnutrition, diarrhoeal illness and other common childhood illnesses; and strengthening surveillance and control of food hazards and foodborne disease by food control and health authorities (WHO 2008; FAO 2008b; WHO et al. 2009). Greater emphasis needs to be placed on protecting the health of particularly vulnerable groups, more particularly young children, pregnant and lactating women. The critical role of the nutritional status of adolescent girls and of women prior to conception and interpregnancy intervals needs to be specifically addressed and has rarely been mentioned. Rural communities and urban areas with high levels of maternal and child undernutrition, as well as communities with high infectious disease burdens from malaria, tuberculosis and HIV deserve specific attention.

Social protection schemes that have proven effective in addressing undernutrition

Droughts or others climate-related shocks frequently force poor families to resort to negative coping strategies (for instance reduction of the quality, safety and quantity of their meals, reduction of the expenditures on health and education, sale of productive assets, etc.) (WFP 2009). These coping strategies generally increase the risk of undernutrition (WFP 2009), in the short- or medium-term and women and children are the first to be affected. Social protection programmes are powerful instruments to link risk reduction and immediate protection measures with efforts to build long-term resilience amongst the most vulnerable groups (Davies 2008), more specifically young children and their mothers. Given the critical role that women play in the nutrition of children, transfers should be delivered through gender-sensitive mechanisms.

Short-term emergency or seasonal safety nets can avoid irreversible losses in human capital, reduce the incidence of negative coping mechanisms and protect the family's access to sufficient, nutritious and safe food. Food and cash-for-work programs prevent poor farmers from selling off their few productive assets during crises, thereby protecting development gains. Social cash transfers, generally delivered by governments on a permanent basis, can help poor families to reduce their vulnerability and may also directly influence nutritional status. Conditional cash transfer programmes in Colombia, Mexico and Nicaragua decreased stunting rates by 7, 10 and 5.5 percentage points respectively (Adato and Hoddinott n.d.). Labour-based productive safety nets and pro-poor insurance schemes can allow poor farmers to protect their productive assets and to gain access to investment opportunities that they would otherwise miss. School-based approaches (school feeding programmes, school gardens, nutrition education, etc.) can support child nutrition through improved diets, food and nutrition education and provide a platform for addressing child health. When children are reached during the critical period between conception and 2 years of age, the irreversible and intergenerational effects of undernutrition can be hindered. Later in life, school-based approaches may support child nutrition through improved diets, food and nutrition education and provide a platform for addressing child health.

Empowerment and social participation within climate-resilient and nutrition-sensitive community-based development

Empowerment and social participation of women and other vulnerable groups is necessary throughout the decision-making, planning and implementing processes. Investments for community food and nutrition security should (WFP et al. 2009):

- Target strengthened legal rights and equal access to resources for both women and men;
- Support responsive institutions grounded in the local context;
- Expand and improve livelihood options;
- Support gender dynamics, gender equality and girls' education;
- Enhance local capacities by building on local, indigenous and traditional knowledge with institutions at all levels; and
- Create a restored, diversified natural resource base and ensure that populations have the capacities and means for a sustainable management of their natural resources.

In addition to a rural focus, attention has to be given to urban and peri-urban areas. The food supply in urban and peri-urban areas can be put at stake by climate change hazards (for instance as a result of the destruction of crops or the interruptions of supply channels). These perturbations can have an important impact on the growing urban and peri-urban populations, in particular the poorest and most vulnerable living in precarious conditions in slums, with no access to social protection or safety nets. Young children, adolescent girls, and pregnant and nursing women in rural, urban and peri-urban areas should receive specific attention.

Nutrition-sensitive disaster risk reduction and management

With increasing risks of climate-related disasters, there is a need to better protect those who are already food and nutrition insecure by developing nutrition-sensitive disaster risk reduction strategies and risk management practices. There is a reservoir of important indigenous and traditional knowledge in hazard-prone communities. Policy-makers and practitioners should capitalize upon this existing knowledge and promote the positive local risk management and coping strategies. In line with the Hyogo Framework of Action (2005) (UNISDR 2005), key areas would be: participatory, nutrition-focused risk assessments and risk reduction plans; effective nutrition surveillance and early warning systems, coupled with early response mechanisms; disaster preparedness for effective response to adverse hazard events and capacity to address nutrition emergencies; contingency planning and stockpiling emergency nutrition supplies; building resilience of food and nutrition insecure communities to disasters. The potential of innovative micro-insurance schemes targeting food and nutrition insecure households should be further explored. Quality climate risk and early warning information should be accessible to communities (with a special focus on women), to decision-makers and to humanitarian stakeholders at all levels. These stakeholders should improve their ability to prepare for and respond to disasters and food and nutrition crises, should be ready to cope with increased demand for support. Innovative examples of climate risk management have already been developed, and could be scaled up and replicated. One example is the Livelihoods, Early Assessment and Protection (LEAP) software application developed in Ethiopia, which allows users to quantify and index the drought and excessive rainfall risk in a particular administrative unit. The software monitors this risk and guides early emergency responses and the scaling up of the Ethiopian Productive Safety Net Programme (PSNP) (Hazell et al. 2010).

Mitigation: Nutrition-sensitive climate change mitigation measures

Climate change mitigation measures need to be put in place urgently in all the sectors, in order to reduce the impacts of climate change on food and nutrition security. The agriculture sector substantially contributes to greenhouse-gas emissions worldwide and therefore offers a significant potential for mitigation. Mitigation strategies in the agriculture sector should be pro-poor and sustainable while avoiding compromising food and nutrition security (FAO 2008a; Tirado et al. 2010; CGIAR 2009).

Many mitigation opportunities in this sector can enhance the adaptive capacity and sustainability of systems contributing to development (CGIAR 2009).

The LMIC require a tailored support to address the challenge of investing more in agriculture and ensuring food and nutrition security for their populations, strengthening the resilience of their food production systems to climate change, whilst also reducing emissions from agriculture. Mitigation measures that bring co-benefits in terms of enhanced food production and access, nutrition and health in LMIC should be further tested and scaled up. These strategies include for instance agro-ecological food production systems, integrated agro-forestry and silvo-pastoral systems, or low-emission stove technology for burning local biomass fuels, which can reduce the risk of acute respiratory tract infections in young children (FAO 2008a; FAO 2006; Wilkinson et al. 2009).

Mitigation strategies that aim to reducing the carbon foot print from the whole food sector through sustainable food production and food consumption and waste reduction should be explored and encouraged (EC 2009; Friel et al. 2009; UNEP 2010). Recognition that climate change mitigation strategies can have substantial benefits for food and nutrition security, health and climate protection offers the possibility of policy choices that are potentially both cost effective and socially attractive.

Finances: Financing nutrition, a sound investment for the future

There is a need for additional investment to address the new challenges posed by climate change on food and nutrition security in low and middle income countries. Existing and emerging Climate Funds should be mobilized to support nutrition-focused adaptation actions and target in priority women and children in communities most at risk of undernutrition. National adaptation plans should ensure adequate budgetary allocations and incorporate the appropriate actions to address nutrition problems. Climate Funds and others private investments should support as well climate change mitigation measures that bring nutrition co-benefits. Better nutrition strengthens communities and local economies and contributes to the achievement of other development and adaptation objectives.

Strategic capacities for policy development, institutional accountability and good governance

A number of policy, institutional and governance issues have considerable influence on food and nutrition security. Reaching and sustaining food and nutrition security in a changing climate requires a multi-sectoral approach involving agriculture, health and social protection. There are also important links to education, water-supply and sanitation as well as to cross-cutting issues like gender equality, governance and state fragility. Nutrition outcomes are good impact indicators for each of these sectors.The cross-sectoral nature of nutrition and the potential negative implications of climate change mitigation actions on nutrition call for increased policy coherence, institutional and cross-sectoral collaboration, at local, national and international levels. Mechanisms that ensure this policy coherence between development, adaptation and mitigation objectives should be explored and implemented at all levels. Effective cross-sectoral planning and solutions should be facilitated by joint efforts among communities and local stakeholders, governmental and public agencies, the United Nations agencies, civil society, private sector and academia, and by developing partnership mechanisms at all levels. It is necessary to strengthen the capacities of the various stakeholders involved in direct nutrition interventions, food production and access, social protection systems and also to improve their ability to prepare for and respond to disasters.

Many LMICs lack the adequate institutional framework and human resources to implement nutrition-based agendas (Benson 2008).

Special efforts are needed to raise awareness on nutrition and climate change among decision-makers and policy-makers, to strengthen national capacities, to bridge the gaps between sectoral institutions. At international level, there is a need for nutrition policy coherence and cooperation to eradicate undernutrition in all its forms (FAO 2008a; Tirado et al. 2010) including both under and overnutrition. Stakeholders involved in the UNFCCC climate change discussions should draw on support from related international fora and initiatives, such as the United Nations System Standing Committee on Nutrition (UNSCN), the Scaling Up Nutrition (SUN) movement, the Committee on World Food Security, the UN High Level Task Force on Global Food Security, the REACH partnership and the International Health Partnership. There is still a gap between affected communities and the national and multilateral debates. It will be necessary to better link the local-level voices, experiences and expertise to the national and international climate change agendas, for adaptation and mitigation to succeed.

Conclusion

Climate change directly affects food and nutrition security, undermining current efforts to address undernutrition, one of the world's most serious but least addressed socioeconomic and health problems. A combination of nutrition-sensitive adaptation and mitigation measures, nutrition-smart investments, increased policy coherence, and institutional and cross-sectoral collaboration can address the threats to food and nutrition security from climate change.

Nutrition-sensitive adaptation and mitigation measures should be integrated with development strategies and programmes. Changes in policies, institutions and governance will be needed to facilitate this intersectoral approach (FAO 2008a; Tirado et al. 2010). Placing people and human rights at the centre of strategies to adapt to and diminish the effects of climate change can enhance thedevelopment and implementation of climate-resilient policies. A rights-based approach engages the rural, peri-urban and urban stakeholders most vulnerable and affected by climate impacts as active participants in this process.

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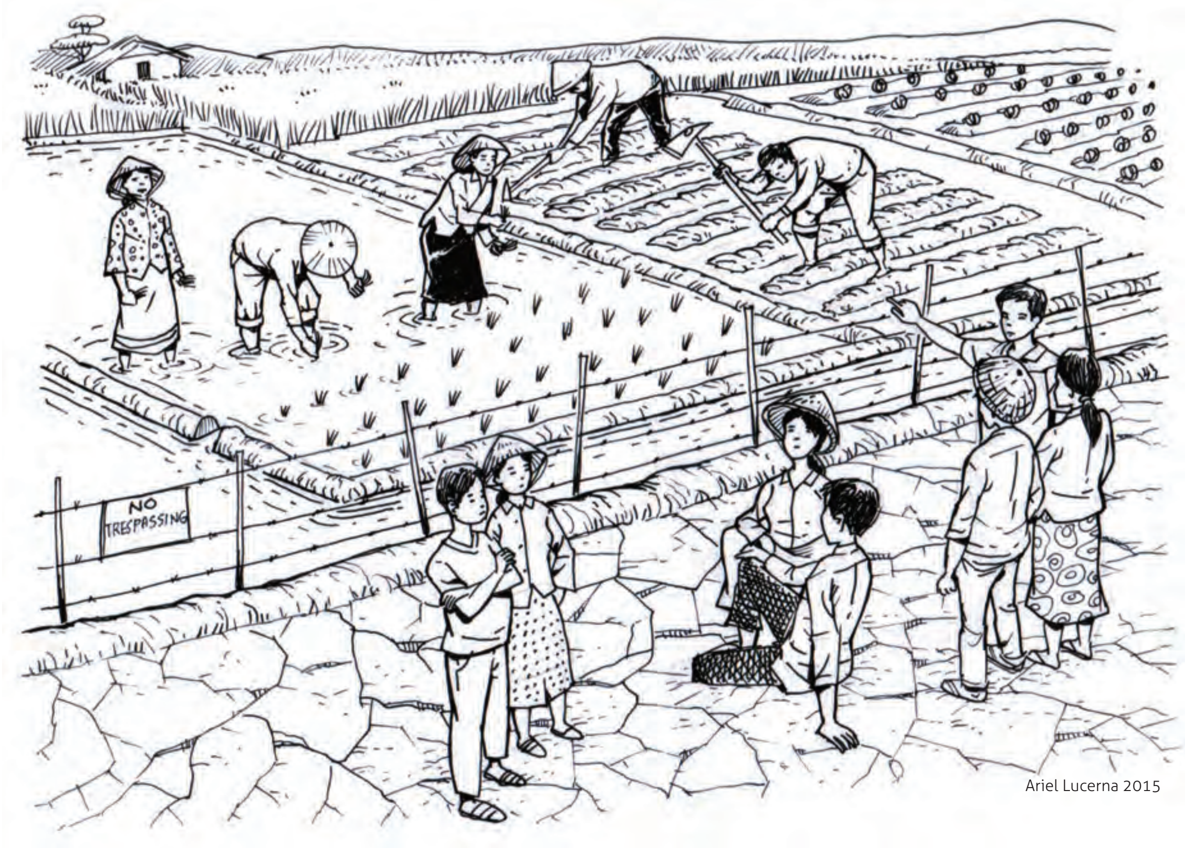

Ways to enhance the adaptation to climate variability at the village level

Adaptation to climate vulnerability

Planned adaptation is essential to increase the resilience of agricultural production to climate change. Several improved agricultural practices evolved over time for diverse agro-ecological regions in India have potential to enhance climate change adaptation, if deployed prudently. Management practices that increase agricultural production under adverse climatic conditions also tend to support climate change adaptation because they increase resilience and reduce yield variability under variable climate and extreme events. Some practices that help adapt to climate change in Indian agriculture are soil organic carbon build up, in-situ moisture conservation, residue incorporation instead of burning, water harvesting and recycling for

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This article was repackaged from the original article entitled *Towards Climate Resilient Agriculture through adaptation and mitigation strategies: Enabling farmers to cope with climate variability through land, water, crop and livestock management in vulnerable districts of India* by National Initiative on Climate Resilient Agriculture of the Central Research Institute for Dryland Agriculture. Refer to the source box towards the end of this article for a complete reference to the original article.

The project aims to enhance resilience of Indian agriculture to climate change and climate variability through strategic research and technology demonstration. Strategic research on adaptation to progressive climate change covers crops, livestock, fisheries and natural resource management. Technology demonstration focuses on participatory evaluation of location specific interventions in vulnerable districts of India to enable farmers cope with current climate variability.

supplemental irrigation, growing drought and flood tolerant varieties, water saving technologies, location specific agronomic and nutrient management, improved livestock feed and feeding methods. Institutional interventions promote collective action and build resilience among communities. Capacity building by extensive participatory demonstrations of location specific agricultural practices helps farmers gain access to knowledge and provides confidence to cope with adverse weather conditions. In this project, an effort is made to marshall all available farm technologies that have adaptation potential and demonstrate them in farmers' fields in most vulnerable districts of the country through a participatory approach.

Village level interventions towards climate resilient agriculture

1. Building resilience in soil

Soil health is the key property that determines the resilience of crop production under changing climate. A number of interventions are made to build soil carbon, control soil loss due to erosion and enhance water holding capacity of soils, all of which build resilience in soil. Mandatory soil testing is done in all villages to ensure balanced use of chemical fertilizers. Improved methods of fertilizer application, matching with crop requirement to reduce nitrous oxide emission.

2. Adapted cultivars and cropping systems

Farmers in the villages traditionally grow local varieties of different crops resulting in poor crop productivity due to heat, droughts or floods. Hence, improved, early duration drought, heat and flood tolerant varieties are introduced for achieving optimum yields despite climatic stresses. This varietal shift was carefully promoted by encouraging village level seed production and linking farmers decision-making to weather-based agro advisories and contingency planning.

3. Rainwater harvesting and recycling

Rainwater harvesting and recycling through farm ponds, restoration of old rainwater harvesting structures in dryland/rainfed areas, percolation ponds for recharging of open wells, bore wells and injection wells for recharging ground water are taken up for enhancing farm level water storage.

4. Water saving technologies

Since climate variability manifests in terms of deficit or excess water, major emphasis was laid on introduction of water saving technologies like direct seeded rice, zero tillage and other resource conservation practices, which also reduce GHG emissions besides saving of water.

5. Farm machinery (custom hiring) centers

Community managed custom hiring centers are setup in each village to access farm machinery for timely sowing or planting. This is an important intervention to deal with variable climate like delay in monsoon, inadequate rains needing replanting of crops.

6. Crop contingency plans

To cope with climate variability, ICAR/CRIDA has developed district level contingency plans for more than 400 rural districts in country. Operationalization of these plans during aberrant monsoon years through the district/block level extension staff helps farmers cope with climate variability.

Project sites

The project is implemented in one representative gram panchayat in each of the 100 districts selected based on major climatic vulnerability viz. drought, floods, heat wave, cold wave, frost and cyclones. The project is implemented by Krishi Vigyan Kendras (KVKs) at district level, regionally coordinated by the Zonal Project Directorates (ZPDs) with overall planning, monitoring and coordination by CRIDA, Hyderabad.

7. Livestock and fishery interventions

Use of community lands for fodder production during droughts/floods, improved fodder/feed storage methods, feed supplements, micronutrient use to enhance adaptation to heat stress, preventive vaccination, improved shelters for reducing heat/cold stress in livestock, management of fish ponds/tanks during water scarcity and excess water are some key interventions in livestock and fishery sector.

8. Weather based agro advisories

Automatic weather stations at KVK experimental farms and mini-weather observatories in project villages are established to record real time weather parameters such as rainfall, temperature and wind speed etc. both to issue customized agro advisories and improve weather literacy among farmers.

9. Institutional interventions

Institutional interventions either by strengthening the existing ones or initiating new ones relating to seed bank, fodder bank, commodity groups, custom hiring centre, collective marketing, introduction of weather index based insurance and climate literacy through a village level weather station are introduced to ensure effective adoption of all other interventions and promote community ownership of the entire programme.

10. Village Climate Risk Management Committee (VCRMC)

A village committee representing all categories of farmers including women and the land less is formed with the approval of Gram Sabha to take all decisions regarding interventions, promote farmers participation and convergence with ongoing Government schemes relevant to climate change adaptation. VCRMC participates in all discussions leading to finalizing interventions, selection of target farmers and area, and liaison with gram panchyat and local elected representatives and maintain all financial transactions under the project.

Source: Towards Climate Resilient Agriculture through adaptation and mitigation strategies: Enabling farmers to cope with climate variability through land, water, crop and livestock management in vulnerable districts of India

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Policy implications and recommendations for climate services design

The lessons we presented in this report suggest a few elements that should generally be part of any effort to develop climate services at a national scale that seek to serve smallholder farmers.

First, involve farmers in the co-design, co-production and co-evaluation of climate services. Evidence from the case studies suggests that needs can be quite context-specific, varying even from one village to the next. What appears as an intuitive initial step—asking end users what they need—is often overlooked. However, giving farmers an effective voice requires more than an initial needs assessment. The informed and sustained engagement of farmers throughout the design, production, delivery and evaluation is needed in order for information products and services to evolve with experience, changing needs and changing capability of climate and other relevant sciences. It means valuing farmers' perspectives; and providing opportunities for engagement with researchers so their requirements can be informed by science, and the provision of services can be informed by their evolving requirements.

This article was drawn from previously published materials entitled *Scaling up climate services for farmers: Mission possible - Learning from good practice in Africa and South Asia* by Arame Tall, James Hansen, Alexa Jay, Bruce Campbell, James Kinyangi, Pramod Aggarwal, and Robert Zougmoré. Refer to the source box towards the end of this article fo complete reference to the original article.

Working with rural communities to integrate their knowledge into production of climate services is at the heart of the co-production effort. Doing this at scale requires efficient mechanisms to engage legitimate representatives of smallholder farmers, and to capture and map farmers' evolving needs.

Second, establish partnerships that bridge the gap between climate, agricultural research and farmers. The co-production of climate services requires sustained interaction and engagement of all parties (climate, research and end users). It has become clear that new institutional arrangements for salience will be required, expanding the boundary of climate service production to both agricultural research and farmers themselves. When end-users' climate service needs are elicited, this often reveals significant gaps between their needs and the information and services that are routinely available. Filling those gaps requires climate expertise for example to: downscale climate information to a scale that is relevant to rural communities, improve prediction skill, or extend prediction to include agriculturally-important variables such as onset or cessation of the rainy season or the distribution of dry and wet spells. However, meeting farmers' needs also involves integrating climate information and agricultural expertise to produce predictions of climate impacts on agriculture, and farm management advisories. While national meteorological services (NMS) have the expertise to produce raw weather and climate information, national agricultural research and extension systems (NARES) are generally in a better position to translate this information into advice and support for farmers. Strong partnerships between national meteorological and hydrological services (repositories of climate knowledge at the national level) and national agricultural research and extension services (repositories of agricultural knowledge and extension support in country) are therefore a pre-requisite to producing information and services that are tailored to farmers' needs. Where such partnerships are not yet formalized, brokering partnership enabling sustained dialogue and is essential to the success of climate services that target farmers. We draw out examples of how case studies attempted to foster these partnerships, but the case studies reviewed do not provide enough evidence about their success, or factors that may limit their success, to address this important issue within the report.

Third, exploit scalable communication channels to reach "the last mile." Once tailored products are developed, the next challenge is to communicate widely to ensure the products reach the majority of farmers in the country or target region. As the case studies reviewed in this report illustrate, a wide range of communication channels can be used to deliver climate-related information and advisories, and to collect farmer feedback. Our experience, and assessment of the literature and case studies, suggest that expanding access to climate services for smallholder farmers is best accomplished through a combination of leveraging the reach and cost-effectiveness of ICTs (e.g. SMS, rural radio, voice recordings, call services); and working through trained staff of boundary organizations (agricultural extension, NGOs, community-based organizations, agri-business) and farmer facilitators who can facilitate the face-to-face dialogue that is needed to deal with the complexities of seasonal climate information. Evidence indicates that two-way communication between farmers and climate serviceproviders is essential, regardless of the communication channels used (Jost 2013; Stigter and Winarto 2013).

Fourth, continuously assess to improve quality of service delivery. To ensure that climate services respond to evolving end-user needs and reflect the changing nature of the sciences involved, projects and programmes need to keep assessing adherence of provided products to local needs throughout the lifespan of the climate services project or programme. Assessment and reassessment should be part of the initial design and be integrated throughout the process of climate services development, particularly including giving farmers an effective voice, and communication approaches to reach more remote farmers. Assessing climate services fulfils at least three purposes. First, it can foster legitimacy and accountability by providing a formal mechanism to capture users' needs and feedback. Second, it informs the iterative process of improving and tailoring climate services to evolving local needs. Third, the resulting evidence of the costs and benefits of climate services can be used to build a case to governments and donors for continued and perhaps increased investment.

Finally, proactively engage, and target the needs of, the most vulnerable and marginalized, particularly women, from the onset. The vulnerability of smallholder farmers to climate risk is a major motivation for much of the recent interest and investment in climate services. Yet the challenges that lead some segments of rural populations to be more vulnerable also tend to make it more difficult to benefit from institutional services, including climate services. In the cases included in this study, the most vulnerable tended to be resource-poor, female and lower caste farmers, marginalized by the boundaries of their own community's sociocultural norms, and invisible to many outsiders. In order to build the resilience of farmers equitably, it is important to proactively target women and other marginalized farmers in the various steps of the design and delivery of climate services programmes, and ensure that they are represented in institutional and governance arrangements.

These five guidelines map out an integrated approach for designing, producing, communicating and evaluating climate services for smallholder farmers.

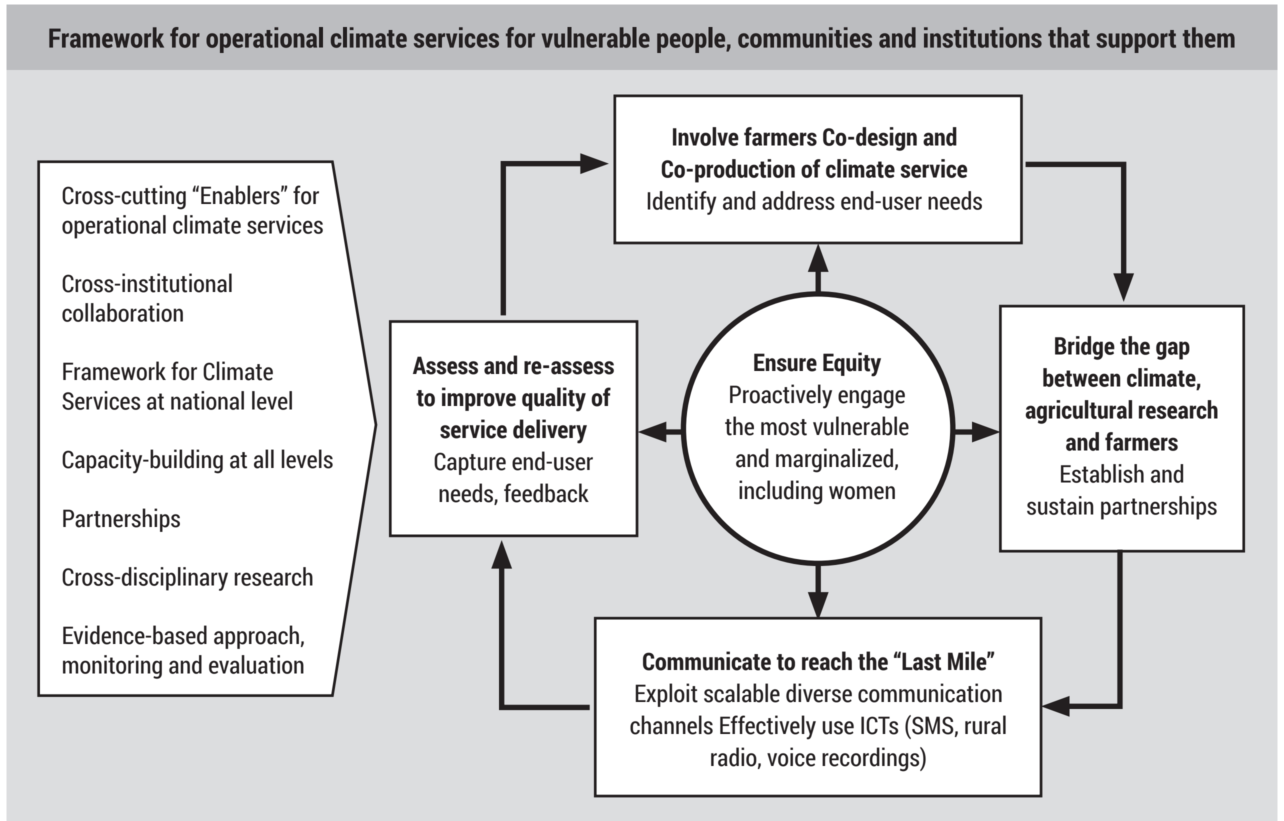

Figure 1. Proposed integrated framework for designing, producing, communicating and evaluating climate services for farmers.

As the cases reviewed in this report detail, reaching large numbers of farmers with climate services that are relevant, usable, credible and valued by end users is "Mission Possible" – but not without challenges. The eight good practice lessons summarize some of the ways in which experiences on the ground are addressing the tenacious challenges to providing climate services that are useful for smallholder farmers in the developing world. The case studies that support these lessons also provide evidence that this endeavour is possible, although challenging. Overcoming the challenges will require collaboration across communities and across disciplines, as well as enabling institutional frameworks within which such collaboration can take place at the national and sub-national levels, towards the production and delivery of end-user relevant climate services. Helping countries establish frameworks for climate services, which enable such collaboration across institutions and their associated ministries, is an urgent priority and perhaps the most difficult challenge.

This report has offered five potent guidelines gleaned from good practice across Africa and South Asia to address the challenges to scaling up climate services for farmers, and guide the efforts of future programmes aiming to support agricultural decision-making through climate information services (see figure 1 on earlier page). These guidelines map out an integrated approach for designing, producing, communicating and evaluating climate services for smallholder farmers.

In a world of exacerbated climate variability and uncertainty, with the greatest impacts anticipated in areas of Africa, Asia and the developing world, equipping and the most vulnerable communities with climate information and advisory services to anticipate climate-related shocks and changes becomes an urgent priority.

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Implications of climate change for land policy

The general messages of the realities of climate change in relation to land tenure are not different form the principles of progressive land policies now widely recognized and promoted by international development agencies. These include the provision of secure land rights under a diversity of forms of tenure, including the recognition of customary rights and the devolution of responsibilities for land registration and management to more local levels; promoting land access for disadvantaged groups including women and indigenous peoples; upgrading of tenure and infrastructure in urban informal settlements; improving equality in the distribution of land; decentralized management of natural resources and inclusive frameworks for stakeholder involvement and management of conflicts; encouragement of equitable rental markets to improve supplies of land; and better governance in land administration, in particular to ensure equitable access to and good use of public land. On the other hand there will clearly be a need for more effective land use regulation in at risk areas which is likely to constrain overall land availability leading to requirements to accelerate provision of land access and secure land and resource tenure elsewhere. In practice however, the relatively high costs of resettlement or compensation for loss of land, and of tenure regularization on a massive scale, coupled with the likelihood of climate change impacts on tenure insecure people in at risk areas may lead governments to neglect questions of tenure

This article was drawn from previously published materials entitled *Climate change and land tenure: the implications of climate change for land tenure and land policy* by Julian Quan and Nat Dyer. Refer to the source box towards the end of this article for complete reference to the original article.

security of vulnerable groups. As a result it is not enough simply to promote a positive land policy response to the risks associated with climate change. What is needed is a more systematic integration of land policy with climate change adaptation planning.

In general terms we consider that there will be a need for tenure policies which provide both a) greater security in land and property rights so as to consolidate and extend people's control over land and natural resource assets and provide incentives for good environmental stewardship, and b) for greater flexibility to accommodate changes in land use and settlement patterns so as to provide clear options for people in the anticipated contexts of greater demographic mobility provoked by climate related threats to human settlements and livelihoods. These two elements of security and flexibility are both important considerations in current land tenure policies and we believe they are not in contradiction.

Critical issues

On the basis of the foregoing discussion of the land dimensions of climate change impacts, this paper identifies three critical problems which land policy needs to address, which cross cut the range of at risk areas in developing countries.

i) The need to address land use and settlement issues in areas facing significant direct risks from climate change, notably low lying coastal areas, including cities and river deltas, and particularly in those areas at serious risk in South Asia. There is a need for both:

   a. provision of secure rights for households to plots of land in safe areas and secure access for local communities to their immediate environments to create incentives for upgrading of infrastructure and for effective natural resource management; and

   b. action to facilitate resettlement in preparation for the large scale displacement resulting from sea level rise and more frequent storms surges and high impact disasters, including inventories of current settlements and available land, documentation of informal rights, assessment of land suitability and climate hazard risks, and action to improve land availability and allocation.

To a high degree both these types of measure will involve increasing the capacity of land administration systems.

ii) The need for accelerated provision of secure tenure arrangements which can enhance households and communities existing capacities to adapt to the impacts of climate change on livelihoods and food security production. This will involve rolling out low cost programmes of tenure regularisation and formalisation on both a household and community basis (according to available capacity and existing customary practice) especially in areas of the semi-arid and sub-humid tropics likely to suffer impacts on food production or facing growing land competition. These measures need to incorporate strengthening of natural resource tenure through group titling or joint management frameworks involving local communities, the state and other natural resource users. Tenure security and natural resource management innovations need to be accompanied by measures to strengthen community capacity for resource management and ensure the uptake of appropriate management techniques and productive technologies. Once again these types of measures will require increases in public capacity for delivery.

iii) Measures to protect the poor and vulnerable from loss of livelihood resources and develop the opportunities available for them to gain direct benefits as a result of climate change mitigation measures, in particular avoided deforestation / reforestation and biofuels development, especially where these are led by market based mechanisms. This will involve development of better legal frameworks for the regulation of these programmes, including achieving better coherence across countries land and forest policies, and developing agreed standards and monitoring arrangements for carbon emissions mitigation which properly address questions of land and resource ownership and access. Actions to ensure group titling in forest areas, or in areas where there is already a diversity of legitimate public and private interests are important recognition of secure rights of access and prior consultation and participation for indigenous peoples in forest area management are important first steps, prior to the wider development of these schemes.

There is a need for targeting of all these measures on women, indigenous groups and other social groups at particular risk because of poverty, weak access or restricted access to land and natural resource assets, existing exposure to natural and other hazards, and limited adaptive capacity. Given the likely increases in mobility, migration and land competition in many areas as a result of climate change, and the fact that the poor are likely to be disproportionately affected by climate change there is a general need to strengthen the governance arrangements over land based natural resources on which the poor and vulnerable depend, in addition to specific measures targeted at women and indigenous groups. This means not only paying attention to lands issues in climate change mitigation planning but ensuring that land tenure and land use management have central places in sustained efforts to improve the governance frameworks for both rural and urban development in the context of climate change.

Land tenure related measures

In responding to these critical problems, a number of specific land tenure and land policy issues which have emerged from the discussion of the land dimensions of issues in climate change adaptation are listed below:

Tenure security issues: providing security through a diversity of forms of tenure, (not only provision of freehold rights through) including granting formal recognition to customary and informal rights; granting tenure security to groups, village communities, producer associations and other collective bodies where appropriate, including for indigenous groups; utilizing low cost methods of land survey and registration; devolving responsibility for documentation of land rights to local bodies; moratoriums on evictions without resettlement or fair compensation, and improved legal remedies against evictions and forced removals; gendered approaches incorporating opportunities for women to register land and joint spousal rights; priority access to home area resources, and negotiated frameworks for access to valuable seasonal and fallback resources for pastoralist and other mobile groups.

Improving land access for the poor: making existing land redistribution programmes work more effectively; better use of government land and eliminating corruption in access to public land; equitable liberalization and regulation of rental markets to encourage land supply and provide greater certainty on both landlords' and tenants' rights; land release schemes in resettlement areas; programmes to guarantee access to household plots and home gardens for the poor; proactive programmes for land access for women and vulnerable groups.

Strengthening the negotiation position of the poor: legal literacy and empowerment; advocacy and intervention by government and civil society organizations to facilitate poor people's access to land distribution schemes and land markets; reducing fees and transaction costs in access to land administration institutions; capacity building for community and residents associations and farmer organizations to play active roles in adaptation planning.

Land and natural resource information: improved inventories of land occupation in urban and rural areas including the informal sector; improved analysis and mapping of natural hazard risks for informal settlements; better inventories of land available for resettlement or temporary relocation.

Integration of land into climate change adaptive planning

Land policy is one key element of adaptation planning, therefore in addition to improving and climate proofing" land policies themselves, land policy measures, including land inventories, tenure regularization, resettlement, and improved land use regulation in at risk areas need to be more fully integrated with NAPAs (National Adaptation Programmes of Action) at national and sub-national levels. In turn adaptive measures need to be more effectively mainstreamed into national development policies and poverty reduction strategy frameworks and into government and international agency planning as a whole, which needs to deliver funding to priority adaptive actions, at a scale and pace commensurate with the evolution of the human need. Note that priority land policy actions for adaptation to climate change are unlikely to be different in essence from land policy's own priorities. However, climate change risks create new demands in terms of the scale and pace of action (e.g. to deliver tenure, security, land for resettlement, squatter upgrading, comprehensive land inventories) prioritization of particular geographical areas and social groups.

In this context of national and regional adaptive planning:

Integrated land and water resource management: while action is needed to conserve water resources and improve soil moisture availability at farm level, water resource availability needs to be assessed and programmes for water management introduced at a variety of territorial scales, including river basins, rural watersheds major cities and informal settlements and irrigation schemes. Resettlement and new land allocation should be accompanied by establishment of water supplies and allocation of water rights, and land and natural resource management, for instance of pastoral groups, musts include access to and management of water resources. Producers and residents groups can also form a basis of water user associations. There is significant potential in organization of region wide collective action and advocacy to secure funding and technical for simple water harvesting and storage technologies, including cisterns collection of run-off and community construction of small-scale dams, as demonstrated by recent programmes in Northeast Brazil. Where water pricing is involved this should to discriminate against vulnerable groups unable to afford the charges. Water rights and water resource management will be particularly important for irrigation schemes subject to diminishing water supplies, which may require substantial reorganization and re-engineering to remain productive under changing conditions.

Special programmes for land and natural resource tenure in semi arid areas subject to climate change: including pastoralist custodianship of rangeland areas, territorial plans for water resource management, formalization of reciprocal arrangements between pastoralist groups, agro pastoralist and settled farmers (including leasehold arrangements to accommodate possible emergence of new agricultural areas e.g. in parts of the Sahel which may experience temporarily increased rainfall and "greening") by building on and extending existing local conventions. The action required goes beyond land and natural resource tenure which needs to be supported by appropriate legislative frameworks (such as the Codes Rural and Chartes Pastoral in West Africa) and incorporate institutional frameworks for participatory governance of natural resources, conflict management, and capacity building and technical support to user groups. Moreover cross border frameworks for land and natural resource access will be needed to address the mobility and migration of affected groups on a regional scale.

Land and carbon mitigation: Although carbon emissions mitigation is not strictly part of adaptive planning, the poor need to adapt not only to climate change but also to the spread of Carbon emissions mitigation measures, including the development of avoided deforestation, carbon offset forestry schemes, and the spread of biofuels, all of which risk undermining existing land rights and reducing land access for poor and vulnerable groups. The lands issues involved in these developments need to be pursued within the coherent policy frameworks which also include planning for climate change adaptation and ongoing poverty reduction. Carbon forestry requires legislative frameworks which take account of land tenure and land access issues, and there is a need for "robust cross scale institutional frameworks" to ensure that market based mechanisms for climate mitigation meet equity and development objectives, within which land and property rights are a central concern. Agricultural land use change and forest preservation by local communities themselves, for instance the adoption of intensive agroforestry schemes should be included as eligible activities for carbon finance, and procedures for local communities and small farmers to gain access to payments for forest conservation, afforestation and reforestation need to be simplified.

Priorities for further research

The above recommendations are based on what we already know about climate change and its likely impacts. Accordingly, they are rather broad. However specific land policy measures and integration of land policy action with wider adaptive planning will need to take place at national and sub-national levels, according to specific sets of climate change impacts and bearing in mind existing legal and institutional frameworks. Consequently there is a need for continuing research to inform improved adaptive planning. Here we outline the major areas for further research on these topics.

Regional impact modeling: insufficient work has been done to run and refine existing climate change impact models to understand the likely land use impacts at regional and sub-regional scales in the developing world. The priority should be modeling of short and medium run impacts, based on existing emissions and projections of future emissions in subsequent decades, which as knowledge and techniques improve should allow for growing confidence about the probable scale of impacts. This in turn is an essential basis for understanding the land use and possible land tenure impacts and policy implications for specific countries and social groups, and the scale and pace at which land policy related measures need to be integrated into wider adaptation planning.

Country and area studies: in depth using 2050 impact scenarios; existing land policies, tenure systems, institutional and governance frameworks, available land for new settlement and productive activities, demographic features and the links with national adaptation plans, strategies and capacity issues, focused on priority areas:

i. Profiles and analysis of areas facing significant risk to human occupation and settlement including the institutional arrangements for adaptation and mapping of informal land rights and settlements, climate related hazard risks and available land for resettlement:
    - due to the direct impacts of sea level rise and changes in flood regimes in low lying coastal areas and river deltas, including urban areas, and in small island states);

- as a result of changes breakdown of existing production and livelihood systems due to temperature rise, and changes in precipitation and water availability with implications for tenure/management/governance systems and possible migration (e.g. the Sahel, Southern Africa, Northeast Brazil, Southern Andes).

ii. Areas which are important targets for emissions reduction, avoided deforestation, carbon sinks and mitigation (Amazon and Congo basins biofuels expansion in Brazil; oil palm and tropical forest in Indonesia/Malaysia)

Climate proofing land policies: Assessments could be conducted of existing land policies and policy development processes on a country or regional basis (linked to regional and sub-regional development organizations and focusing on countries most at risk) to determine how effectively they can cater for climate change related risks and how they may need to change. The coherence of land policy with related areas including agricultural, forest and environmental management policies is a key concern.

Thematic research to inform specific aspects of adaptation planning: As a result of the analysis of possible land related climate change impacts, we have also identified a number of areas for thematic research in different regions from which important cross-country lessons for adaptation planning might be learnt:

- How land policy can facilitate mobility and resettlement in climate change affected regions (including cross border land and territorial policies; negotiated frameworks for inter-group conflict reduction territorial governance).
- Water management in affected regions including changing patterns of demand and supply, existing institutional arrangements, water rights and water pricing, the potential role of collective action and civil society organisations, and impact = adaptation scenarios for water supply and drainage in informal urban settlements and for irrigation schemes likely to be affected by accelerated glacial melt and changing flood regimes.
- Land access and climate change mitigation: research the position of small farmers and forest communities in relation to forest management, carbon storage, energy production and biofuels development and alternative land uses, with a view to improving the opportunities and mechanisms by which the poor in developing countries from low carbon economic development.

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Climate change and land tenure: the implications of climate change for land tenure and land policy
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Ariel Lucerna 2015

Stepping up to the challenge: Facing global climate change and food security

There are several complex and interrelated challenges and barriers to achieving global food and nutrition security in an increasingly variable climate. Without urgent action for mitigation and adaptation, the world faces more loss and damage and this will further threaten the productive capacity and long-term viability of smallholder farmers.

The Fifth Assessment Report (AR5) of the International Panel on Climate Change (IPCC) tells us in stark terms that climate change is impacting food security now and that it is no longer a hypothetical future scenario. It is also accepted that the negative effects of climate change are projected to affect communities that have the lowest capacity to adapt, yet have the highest need to increase production, in order to secure food and nutrition security (Vermeulen 2014). The report states that increases in climate extremes exacerbate the vulnerability of food insecure populations and anticipates increasing impacts on agriculture and food systems. In the future, the possibility of localized warming of more than 4°C (above pre-industrial levels) will severely compromise the ability of agriculture and ecosystems to deliver food and

This article was drawn from previously published materials entitled *Stepping up to the challenge – Six Issues facing global climate change and food security* by Karl Deering. Refer to the source box towards the end of this article for a complete reference to the original article environmental services — even with adaptation — and this will pose significant risk to food and nutrition security. Considering that food insecure small-scale producers will be the most adversely affected by climate change, it becomes obvious that policy and practice will need to move in their favour.

In 2015, governments will aim to agree on a new sustainable development framework that includes a set of longer-term Sustainable Development Goals (SDGs), a future climate change agreement under the United Nations Framework Convention on Climate Change (UNFCCC), and a post-2015 framework to address disaster risks. Collectively, these processes provide a unique opportunity to fundamentally shift course towards global and national climate-resilient development pathways. Whether these actions promote food and nutrition security in the face of climate change will be one of the key benchmarks in assessing success — six issues below will be critical to this.

Key Issues:

1. Scale up proven action and practice;
2. Ensure equitable outcomes for women;
3. Give decision-making power to farmers;
4. Enhance nutrition security, not just food security;
5. Make mitigation an opportunity for, rather than a threat to food security;
6. Support markets and value chains for low income producers and consumers.

Scale up proven action and practice

One of the greatest challenges we face is how to ensure increased investment in sustainable, productive, equitable and resilient agriculture, through climate finance and agriculture finance.

Just meeting projected increases in demand for agricultural products will require significant levels of private and public investment. However, adaptation to climate change within the agricultural sector entails additional costs. These have been estimated at USD 7 billion per year to 2050 (Nelson et al. 2009), USD 11.3 — 12.6 billion per year in the year 2030 (Wheeler and Tiffin 2009) and a cumulative USD 225 billion to 2050 (Lobell et al. 2013). Policy-makers and investors, from multilaterals to bilaterals to the private sector and beyond, must find better ways to reach the poorest and most vulnerable, who invest more time and effort in securing food and nutrition for their families than most people in the world. It is farmers, fisherfolk and pastoralists who develop the most enduring solutions, so it is logical that new investments should link with these proven approaches. How can we do this? What are the roles of different institutions, from local to global levels, in connecting finance with farmer-led good practice — and what are the models of cooperation required? Given the IPCC's most recent findings, how do we get a bigger share of climate finance, including private finance, into adaptation — particularly adaptation driven by the world's poorest producers?

Take technology transfer, for example. This is an inherently unequal process whereby one party provides solutions to another. How can we move to genuine co-generation of technologies? Where and under what circumstances is "transfer" of hardware or scientific knowledge absolutely necessary? How can we support capacity-building for technology application and south-south cooperation to ensure that approaches and technologies are sustainable and equitable, in the sense that they are delivering positive outcomes for the poorest?

Ensure equitable outcomes for women

Persistent and growing inequality is an unacceptable truth in global development—particularly considering that we have proven ways to address it.

Biased and discriminatory practices surrounding women's access to land and other natural resources is a key driver of inequality. The Food and Agriculture Organization of the United Nations (FAO) estimated that if women had the same access to productive resources as men, farm yields could increase by 20-30% and that global hunger could be significantly reduced as a result (FAO 2011). But while gender discrimination in agricultural policy and practice must be tackled, this cannot be achieved by targeting women as instruments for boosting yields. More thoughtful attention must be afforded to interrelated issues of power, social structure and relations that define interactions between women and men (Bernier et al. 2013). Social analysis must become much more comprehensive—and it must be active analysis, whereby policy-makers and service providers themselves internalize the challenges. Because adaptation decisions depend on opportunities governed by the varied and complex interplay of social relations, institutions, organizations, and policies (Perez et al. 2014), it is imperative that our understanding of inequality in agriculture advances.

Given the potential for improvement, how do we lock in guarantees that inequality (and particularly gender-based inequality) is addressed in policy formulation and implementation? On the cusp of 2015, we have emerging and long-existing paradigms such as climate-smart agriculture, agroecology and sustainable intensification that pay little more than lip service to the need for balancing household and community decision-making power and delivering services, incentives, resources and rewards equally to women and men. For example, what approaches do we take to ensure equal access to climate and agriculture information and advisory services? How do we best address gender gaps through frameworks such as the Voluntary Guidelines to support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security (FAO 2004)—or through national legislation, good practice protocols or social and environmental safeguards that will drive good practice and raise standards?

Give decision-making power to farmers

Some 475 million farms, or between 80-90% of the total number globally, are under two hectares in size (Lowder et al. 2014). With the IPCC's Fifth Assessment Report stating that vulnerable small-scale producers are likely to be adversely affected by increasing climate extremes, it is imperative that these producer communities are prioritized with appropriate policies.

What have we learned from employing social learning approaches; improving farmer field and business schooling; building collectives and local institutions and connecting farmers with village savings and loans associations? What are the dividends for farming communities when there is transparent and accountable governance at local levels that considers their needs and understands the risks they take? What are the demand-driven models that work? Participatory methods are a proven success and approaches such as participatory scenario planning thus become crucial. This form of planning breaks through orthodox approaches, as it puts communities and service providers in control of generating knowledge—providing opportunities to address inequitable service delivery in the process (CARE 2012). It allows the consideration of indigenous knowledge and carries considerable advantages as relationships between communities, local authorities, ministry officials and meteorological officers are brokered, often for the first time. How can we ensure innovations such as these are brought to scale?

Giving decision-making power to farmers needs to extend beyond generation of knowledge on the farm. How do we develop the capacity and profile of farmers' groups to effectively engage in well-informed agricultural (and related) policy processes that facilitate demand-driven technologies that address climate change and food security? What more can be done to ensure compliance by all development actors with formal and customary law that is designed to protect the most marginalized and poorest? Both statutory and customary rights to lands, territories and resources, including indigenous genetic resources, which local communities have traditionally owned, occupied or otherwise used or acquired, must be upheld if meaningful decision-making power is to rest with farming communities.

Enhance nutrition security, not just food security

With current attention focused on global food crop forecasts, it is increasingly necessary to stress that nutrition outcomes for the poorest and most vulnerable — and not simply production increases to feed a growing global population — remain primary goals.

And because women and girls are disproportionately affected by inadequate nutrition — especially in the global South (particularly in the context of crises) — the need for rights-based and empowermentbased approaches to food and nutrition security becomes acute. Women effectively translate enhanced knowledge into improved nutrition outcomes. Compelling evidence from Bangladesh, for example, demonstrates that child stunting can be reduced by up to 4.5% with approaches that address the empowerment and capacities of women (Smith et al. 2012). With this in mind, how can interventions be planned so that they are nutrition specific or sensitive, and so that every effort is made to reduce chronic malnutrition, one of humanity's greatest challenges?

There are also significant agronomic adjustments and adaptations that can be promoted to improve nutrition outcomes. Among the crops identified by CGIAR research centers as having particular potential to achieve positive nutritional outcomes in a warming world are cassava, bananas, barley, cowpeas, lentils, and millet (Thornton 2012). Home gardens, including the cultivation of micronutrientrich vegetables like orange-fleshed sweet potatoes, and the keeping of small livestock are examples of agricultural interventions particularly accessible to women and likely to enhance household nutritional outcomes. So what kinds of investments and policy adjustments are required to advance the uptake and scale out of these approaches, which are at the same time climate and environmentally sensitive, nutrition positive and gender transformative?

Make mitigation an opportunity for, rather than a threat to food security

When countries come forward with their mitigation pledges for the future, it will be critical to observe the role that agriculture will play and critical that marginalized and food-insecure farming families do not bear the burden of mitigation targets.

The UNFCCC encourages all parties to come forward with voluntary mitigation pledges for 2020 under the Copenhagen Accord. Political impetus has grown through the Durban Platform for Enhanced Action, the subsequent Warsaw Conference, a series of ministerials during 2014 and the UN Secretary General's Climate Summit in September 2014. While more than 100 countries have made pledges, few include mitigation actions in agriculture, even though there are considerable opportunities, as detailed for example in the UNEP 2013 Emissions Gap Report. As a sector, mitigation measures in agriculture could make up between 6.5-25% of the overall contribution necessary for closing the current gap between business-as-usual emission levels and levels that meet the goal to stay below a 2°C (ideally a 1.5°C) temperature increase (UNEP 2013).

A key challenge for governments, farmers and the private sector is to undertake mitigation actions that enhance rather than reduce food security, particularly for poor producers and consumers. Which actions might be "best bets" and what policy support can provide the best incentives? Many actions to improve resilience and adaptation result in mitigation benefits; in some contexts, key actions that deliver for both mitigation and food security include improved pasture management, increased nutrient and water use efficiency and increased use of trees and perennials on farms. It is important to note that poor smallholder farmers are insignificant contributors to carbon emissions and they should not be obliged to reduce emissions as a precondition of financial or technical support. Some techniques appropriate to their circumstances can enrich the carbon stored in their farming landscape—how can we work with these farming communities to enable them to develop these techniques while not compromising the priority of their realization of food and nutrition security?

Support markets and value chains for low-income producers and consumers

With food security inextricably linked to income, it is important to ensure the development of local, gender and nutrition sensitive, sustainable value chains.

Maximizing climate investments in agriculture to ensure sustainable economic growth offers opportunity. But what financial services and risk management options are available for small-scale producers? How do we ensure they are accessible and that there is inclusive access to finance and markets?

Value chains represent a critical lens by which we can understand how a product moves from producer to customer. This perspective provides an important means to understand commercial and socioeconomic relationships, mechanisms for increasing efficiency, and ways to enable business to increase productivity and add value. Additionally, it provides a reference point for improvements in services and the business environment. There are significant opportunities for pro-poor initiatives that build resilience to climate change, while linking small businesses with markets. Value chains sit at the core of high-impact and sustainable initiatives that can improve productivity, competitiveness, entrepreneurship, and small and medium enterprise growth. The productivity and efficiency of agricultural value chains are thus essential for the success of rural economies and to the incomes of the poorest. What kinds of investments in value chain development can deliver increased returns to the primary actors — the smallscale producers who are often the poorest and most vulnerable?

How can we build on good practice in value chain development that increases socioeconomic equity and protects and enhances environmental integrity and natural resource bases? With climate change and weather extremes now the "new normal", how do we ensure that value chains and market engagement work plays a more central role in risk management for vulnerable farming communities?

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chapter 3

Landscapes and ecosystems services under pressure

- From climate-smart agriculture to climate-smart landscapes
- Climate-smart landscapes: Opportunities and challenges for integrating adaptation and mitigation in tropical agriculture
- Addressing synergies and trade-offs of climate-smart agriculture in agricultural landscapes
- Multiple benefit approaches building resilience alongside other benefits
- Where the land is greener: Experiences contributing to sustainable land management
- Climate change and biodiversity for food and agriculture
- Biodiversity and organic agriculture: An example of sustainable use of biodiversity
- Climate change and transboundary pests and diseases
- Livestock and climate change
- The potential for mitigation of GHGs in livestock production systems
- Adaptation and mitigation strategies in the livestock sector
- Fisheries and aquaculture in our changing climate
- Climate change, fisheries, and aquaculture
- Strategies for adaptation to climate change
- Ecosystem-based approaches and adaptation: Compilation of information

Landscapes and ecosystems services under pressure

Healthy landscapes support livelihoods, food security, and ecosystem functions. The adaptation and mitigation potential of agricultural landscape is now increasingly valued. As the climate changes, the value of biodiversity within our ecosystems for food production will increase. Genetic resources are vital for local communities, researchers and breeders in adapting food and agricultural production to changing needs. This chapter outlines new approaches to tackle these new challenge – from building climate-smart landscapes and tackling pest and disease - to addressing synergies, trade-offs and opportunities to build resilience within ecosystems and sequester carbon within food production value-chains.


Ariel Lucerna 2015

From climate-smart agriculture to climate-smart landscapes

Climate-smart and landscape approaches

The links between agriculture and climate change have been well documented (major reviews cited in Beddington et al. 2011), and agriculture must play a major role in global efforts to address both adaptation and mitigation. But including climate change objectives requires new approaches to agricultural development that more explicitly address ecosystem health and resilience, and action and impacts that can be realized at scale. This introduction briefly summarizes those agriculture-climate change links and the implications for 'climate-smart' agriculture, and then taps the experience of integrated landscape initiatives to propose a 'climate-smart landscape' approach that will be elaborated in the rest of the article.

This article was drawn from previously published materials entitled *From climate-smart agriculture to climate-smart landscapes* by Sara J. Scherr, Seth Shames and Rachel Friedman. Refer to the source box towards the end of this article for a complete reference to the original article.

Climate change and agriculture

Climate change will influence crop distribution and production and increase risks associated with farming. Crop yields have already experienced negative impacts, underlining the necessity of taking adaptive measures (Lobell et al. 2011; Nelson et al. 2010). While a few areas, mainly in temperate latitudes, may experience improved conditions for production, globally, climate change is expected to reduce cereal production by 1% to 7% by 2060 (Parry 2007). There is also substantial variation in likely impacts by crop, irrigated versus rain-fed agriculture, and geographic region (Nelson et al. 2010). At least 22% of the cultivated area under the world's most important crops is projected to experience negative impacts from climate change by 2050, with as much as 56% of the land area in sub-Saharan Africa (Campbell et al. 2011). Impacts may be relatively small up to 2050, but are expected to become progressively worse in the second half of the century (Easterling et al. 2007). Beyond the changes in crop production and yield associated with climate change, there are other areas that require adaptation efforts. Climate-induced water scarcity from changes in temporal and spatial distribution of rainfall could lead to increased competition within the agriculture sector and with other sectors (Hanjra and Qureshi 2010). Moreover, addressing this and other challenges would require modifying physical infrastructure, such as irrigation systems and altering the design and location of storage facilities (Hanjra and Qureshi 2010; Antle and Capalbo 2010). Increased risk from flood and droughts, and shifting fire regimes all pose additional threats to agricultural production (Falbon and Betts, 2010; Peterson et al. 2011). Uncertainties in climate regimes could also influence how farmers make decisions, and whether they invest in necessary inputs and resources for their land.

Meanwhile, roughly 30% of the world's greenhouse gas emissions come from land use (Smith et al. 2007). An estimated 18% come from land use change (primarily deforestation) and another 10% to 12% from crop production (soil erosion and tillage, nitrogen fertilizer, and paddy rice cultivation). Livestock production (from animal digestion, feed production, manure management, and forest cover loss) contributes about 14.5% of global greenhouse gas emissions and nearly half of the agriculture sector's emissions, from enteric fermentation and land clearing (Smith et al. 2007).

Land use represents the largest climate mitigation potential in many countries. Indeed, only land-based carbon sequestration efforts currently offer the possibility of large-scale removal of greenhouse gases (GHG) from the atmosphere, through photosynthesis and carbon sequestration in soils and perennial plants. Agricultural soil carbon accounts for 89% of the technical sequestration potential, representing an estimated potential of between 5.5 and 6 gigatons of CO_2 emissions per year, which roughly equals agriculture's total yearly contribution to global emissions (Smith et al. 2007). Significant sources of emissions reductions include improved feed systems and manure management, more efficient fertilizer use, reducing deforestation and wetland conversion, and restoring degraded lands (Smith et al. 2007). Changes in land management and land use may also moderate local and regional climate through changes in albedo, evapotranspiration, soil moisture and temperature (Desjardins et al. 2007). Moreover, within agriculture, many adaptation measures have significant mitigation co-benefits. For example, increasing soil organic matter improves adaptive capacity by increasing soil water holding capacity and soil fertility, while also sequestering carbon (Falbon and Betts 2010).

Climate-smart agriculture

As research and policy links between climate change and agriculture have advanced, 'climate-smart agriculture' has emerged as a framework to capture the concept that agricultural systems can be developed and implemented to simultaneously improve food security and rural livelihoods, facilitate climate change adaptation and provide mitigation benefits. Since it emerged in 2010, the development of this idea and use of the term itself, has been led by international institutions, particularly the United Nations Food and Agriculture Organization (FAO) and the World Bank (FAO 2010; Bank 2011). The Consultative Group on International Agricultural Research (CGIAR) has provided leadership to the international research community as the idea has matured (Nelson et al. 2010; Moorhead 2009; Vermeulen 2010).

While newly framed as a concept for the climate change and agricultural development communities, climate-smart agriculture includes many of the field-based and farm-based sustainable agricultural land management practices already in the literature and in wide use, such as conservation tillage, agroforestry, residue management, and others (Campbell et al. 2011; Bleker 2011; FAO 2010; Bank 2011; Milder et al. 2011; Pye-Smith 2011). Most of the focus of climate-smart agriculture has been on the implementation of these field and farm practices, and the ways that they can be improved in the context of a changing climate. Many others are engaged in the discourse on agricultural practices for climate change adaptation and mitigation, but without using the climate-smart terminology (Easterling et al. 2007; Smith et al. 2007; Delgado et al. 2011; Lal et al. 2011; Scherr and Sthapit 2009).

However, climate-smart agriculture requires actions beyond the farm scale. One element of FAO's definition is 'adopting an ecosystem approach, working at landscape scale and ensuring inter-sectoral coordination and cooperation' (FAO 2010). In the World Bank's version, climate-smart agriculture includes 'integrated planning of land, agriculture, fisheries, and water at multiple scales (local, watershed, regional)' (World Bank 2011). Yet while landscapes are clearly considered a key component of the climate-smart conceptual framework, there have been few efforts to elucidate the mechanisms to implement climate-smart landscapes.

Integrated landscape management

Parallel to development of the climate-smart discourse has been the emergence of integrated landscape management as an organizing framework for action and policy within the agricultural development and conservation communities (LPFN 2012; Scherr and McNeely 2008). Integrated landscape management approaches work deliberately to support food production, ecosystem conservation, and rural livelihoods across entire landscapes. These are known under various terms including ecoagriculture, landscape restoration, territorial development, model forests, satoyama, integrated watershed management, agroforestry landscapes, and the ecosystem approach to managing agricultural systems, among many others. While differing somewhat in focus, all of these landscape approaches have five elements in common (Table 1).

Table 1. Elements of integrated agricultural landscape management (LPFN, 2012)
1) Landscape interventions are designed to achieve multiple objectives, including human well-being, food and fiber production, climate change mitigation, and conservation of biodiversity and ecosystem services
2) Ecological, social and economic interactions among different parts of the landscape are managed to seek positive synergies among interests and actors or reduce negative trade offs
3) The key role of local communities and households as both producers and land stewards is acknowledged
4) A long-term perspective is taken for sustainable development, adapting strategies as need to address dynamic social and economic changes
5) Participatory processes of social learning and multi-stakeholder negotiation are institutionalized, including efforts to involve all parts of the community and ensure that the livelihoods of the most vulnerable people and groups are protected or enhanced (Pye-Smith 2011)

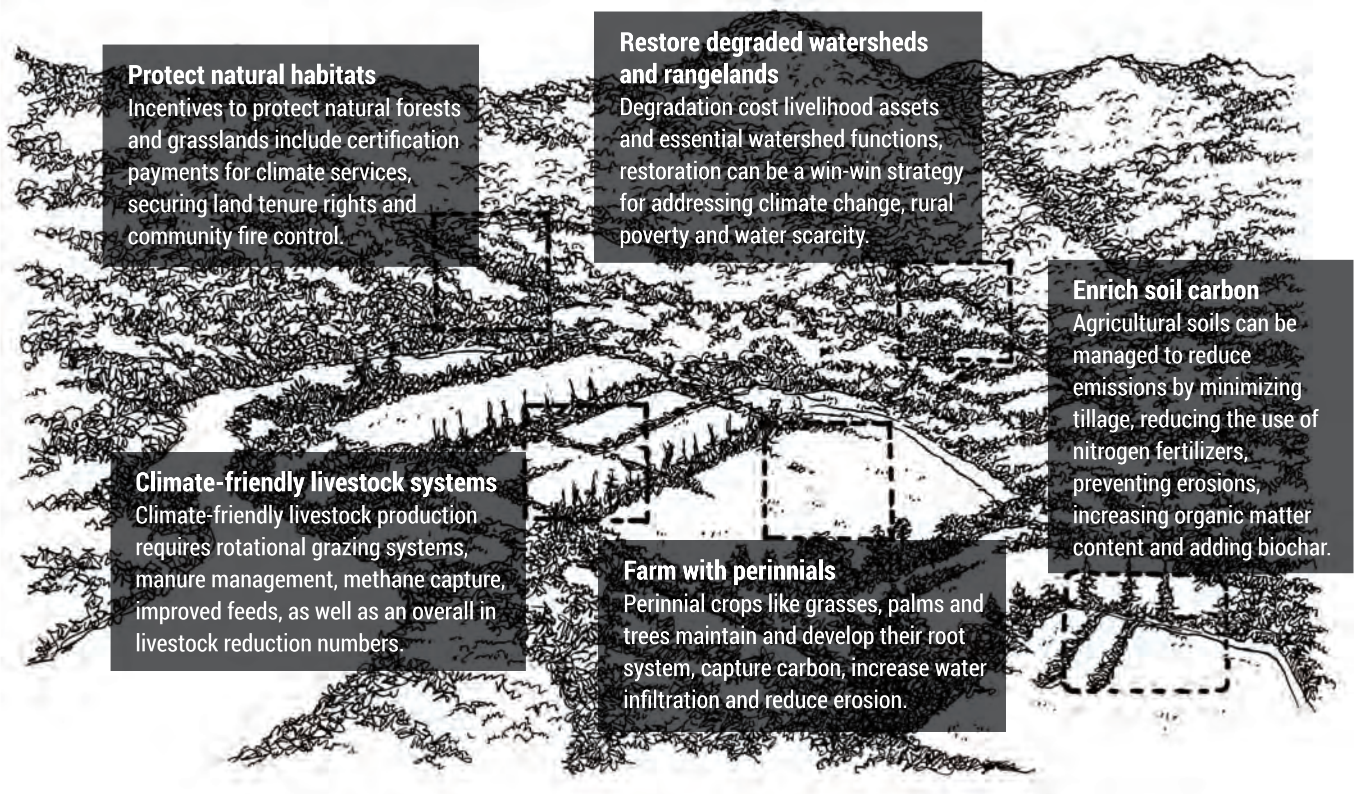

Figure 1. Components of a climate-smart landscape (Shames et al. 2011)

Climate-smart agricultural landscapes

The integrated landscape approach offers a strategy to achieve climate-smart agriculture objectives at scale and in all its dimensions. Through climate-smart agricultural landscapes, important synergies for agricultural production, climate adaptation and mitigation, as well as other livelihood and environmental objectives, can be generated through coordinated action at farm and landscape scales (Figure 1).

The next section describes the key features of integrated landscape management as they relate to climate-smart objectives.

Key features of climate-smart agricultural landscapes

Climate-smart agricultural landscapes operate on the principles of integrated landscape management, while explicitly integrating adaptation and mitigation into their management objectives.

Climate-smart practices at field and farm scale

Climate-smart landscapes are comprised of a variety of field and farm practices, in different land and tenure types, that support both adaptation and mitigation objectives. These practices include soil, water and nutrient management along with agroforestry, livestock, husbandry, and forest and grassland management techniques (FAO 2010; Scherr and Sthapit 2009; Branca et al. 2011; Nkonya et al. 2011; TerrAfrica 2010).

Building soil organic matter is critical for increasing agricultural resilience to climate change. Minimal tillage and using cover crops and crop residues enhance the organic matter stored in soil, while also supporting biological processes and nutrient and hydrological cycling (Milder et al. 2011; Hobbs and Govaerts 2009). Farming with perennials that develop root and woody biomass can substitute for an annual tillage regime, providing year-round ground cover and retaining organic matter and water in soil. Transition from annual crops to fields of perennials has been estimated to increase soil carbon by 50 % to 100 % (Glover 2010). Soil is the third largest carbon pool on earth's surface, and so maintaining and enhancing this stock is essential for mitigation efforts (Scherr and Sthapit 2009).

More efficient management of water, a resource threatened by climate change, is also critical for reaching the adaptation and livelihood goals of climate-smart agriculture. Best practices for irrigation, water-harvesting technology, and terrace or contour farming systems can contribute to improved water-use efficiency and conservation (Milder et al. 2011). Incorporating the shifts in hydrologic regimes and water availability due to climate change into the design and management of water systems will enhance adaptation (Falbon and Betts 2010). Particularly in semi-arid and arid regions, where water resources are already a concern, investment in irrigation increases production, reduces variability, and may spur additional investment in agriculture (Nkonya et al. 2011). Improved design, construction processes and water delivery mechanisms can greatly reduce the very high GHG emissions associated with conventional irrigation systems.

Employing integrated nutrient management principles, such as green manures, planting nitrogen-fixing crops, and incorporating livestock manures into the soil, decreases the amount of nitrogen lost to runoff and emissions of nitrous oxide. Applying these management principles can serve adaptation needs by improving soil quality, while also decreasing farmers' costs and dependence on outside inputs. Organic farming and use of non-synthetic inputs, can increase the amount of carbon and nitrogen retained in the soil by 15% to 28% and 8% to 15% respectively, simultaneously reducing the costs of inputs for farmers (see Milder et al. 2011).

Agroforestry, the use of live fences or intermingled crops and trees, is another strategy to achieve climate-smart objectives. Agroforestry and tree crops increase resilience of local communities by providing a diversity of fruits, nuts, medicines, fuel, timber, nitrogen-fixation services, fodder, and habitat. Furthermore, these economically useful trees and shrubs can reduce soil erosion and maintain higher levels of biomass than annually tilled crops (through extended growth periods and root systems), also storing more carbon (Milder et al. 2011).

Livestock management strategies are particularly critical for climate-smart agriculture. Improved pasture and grassland management, including rotational grazing, regenerate vegetation and restore degraded land which will be critical for climate change resilience. They also contribute to mitigation through carbon sequestration in deep-rooted vegetation and soils. For better manure management, converting manure to biogas provides the added benefits of an alternative energy source with fewer negative health impacts from cooking, heating, and lighting. Improved feed mixes and nutritional supplements can decrease methane emissions; however this is more feasible at larger scales of operation.

Diversity of land use across the landscape

A second feature of climate-smart landscapes is a high level of diversity. This includes land cover, land use, and species and varietal diversity of plants and animals. Diversity has several climate mitigation and adaptation functions: (1) to reduce risks of production and livelihood losses from erratic and harsh climatic conditions; (2) to utilize areas of the landscape strategically as emergency food, feed, fuel, and income reserves; and (3) to sustain minimally disturbed habitats within the landscape mosaic that also serve as carbon stocks.

Reduce risk

Diversity of land uses and species can reduce ecological risks associated with homogeneous crop cover, in terms of pests and diseases and vulnerability to unexpected weather conditions. Improving genetic diversity on farms, by increasing the number of different crops grown or the number of varieties of the same crops, also provides important climate adaptation and risk management benefits (Baily and Purcell 2012; Lipper et al. 2010). Crop genetic diversity improves the chances that some varieties will be suited to shifts in temperature, precipitation, and salinity regimes caused by climate change (Jackson et al. 2010). Moreover, having a portfolio of diverse food and income sources, from crops, livestock, trees, and non-cultivated lands can cushion households and communities from climatic (and other) shocks (Ureta et al. 2012; Bernazzani et al. 2012).

Provide strategic food and feed reserves

Livelihood resilience of households and communities can also be enhanced through access to diverse sources of food, feed and employment during episodes of adverse climatic conditions. Wild plant species in farms, forests, savannahs and wetlands contribute significantly to the diets of many of the poor in developing countries, and these food sources, particularly the 'famine foods' such as wild greens, tree fruits, and roots, play an important role in supplementing diets during periods of climate-induced scarcity (Bharucha and Pretty 2010). Species commonly used as food and feed reserves are hardier, have better (or in situ) storage characteristics, or lower demand for purchased inputs. Communities and local authorities can allocate lands for community and local district grazing reserves. Bush meat found in forests and fish from freshwater and coastal resources can be important sources of protein when climate disrupts agricultural systems.

Sustain perennial habitat as carbon stocks

The dominant farming systems today involve annual plant species. Maintaining other types of land cover throughout the landscape, such as perennial grasslands, woodlands, forests, or wetlands improves ecological resilience in terms of watershed functions and habitat for wildlife important for local livelihoods, tourism or biodiversity conservation. Maintenance or expansion of land area in these types of perennial systems is also one of the most effective ways to sequester carbon and reduce emissions from the landscapes (Scherr and Sthapit 2009).

Management of land use interactions at landscape scale

The third important feature of climate-smart landscapes is management of land use interactions to enhance adaptation and mitigation. Stakeholders and planners must identify, negotiate and manage the impacts of different land uses and management on other land uses and users in the landscape. Active monitoring and management can reduce conflicts and generate synergies that help sustain stakeholder engagement in landscape management. The main benefits of this focus on landscape interactions are: (1) to enhance field-level benefits of climate-smart practices, (2) to secure ecosystem functions, and (3) to enhance the effectiveness of climate mitigation efforts.

Implementing climate-smart agricultural landscapes

To implement climate-smart agricultural landscapes with the features described above (that is, to successfully promote and sustain them over time, in the context of dynamic economic, social, ecological and climate conditions) requires at least four institutional mechanisms: multi-stakeholder planning, supportive landscape governance and resource tenure, spatially-targeted investment in the landscape that supports climate-smart objectives, and tracking the multiple dimensions of change to determine if social, economic, ecosystem and climate goals are being met at different scales.

Enhance field-level benefits of climate-smart practices

Intentional planning of the spatial arrangements of landscape elements can enhance field-level results (Lovell et al. 2011). Agricultural productivity is impacted by the land uses surrounding farms, where field margins, riparian buffers, and forest edges can harbor pest predators or beneficial insects (Harvey 2007). For example, forest fragments adjacent to agricultural land uses increase and stabilize pollination services (Ricketts et al. 2008). Agricultural nutrients and sediment can be managed to protect downstream fisheries, while upstream crop, livestock and forest production can be managed to improve the timing and flow of water for irrigation downstream. Methane from livestock wastes may be used to replace fossil fuels in local agro-processing facilities.

Secure ecosystem functions

Natural and semi-natural habitats, such as riparian areas, woodlands and wetlands, can be sited and managed to provide ecological connectivity for water and nutrient flows, and improve habitat conditions for wild plant and animal species and beneficial microorganisms. As climate change intensifies, connectivity of wildlife habitats and hydrological resources will become increasingly important as an adaptation strategy (Bernazzani et al., 2012; Millar et al. 2007). Agricultural production practices need to support, rather than block, this connectivity. Large-scale rainwater harvesting can be designed to provide water for domestic household and environmental uses, as well as for irrigation. Animal and human disease control requires effective agricultural waste and water management across the watershed.

Enhance effectiveness of mitigation efforts

In addition to its importance for climate change resilience, managing land use dynamics across the landscape is critical for terrestrial mitigation efforts. Perhaps the land use interaction of most prominent concern in the climate community is that between agriculture and forests within the context of efforts to develop Reduced Emissions from Deforestation and Degradation (REDD) programs. Strategies for climate change mitigation and adaptation that seek to sustain forest cover inherently require participation of farmers and other stakeholders in agricultural systems. Specific on-farm agricultural practices sequester relatively small quantities of GHG compared to forest conservation. However, when agriculture and forest development are linked together as part of an integrated landscape livelihood strategy that highlights food security, adaptation, livelihood and other environmental objectives, overall deforestation and GHG emissions can be reduced more effectively and sustainably (Shames et al. 2011).

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Climate-Smart Landscapes:
Opportunities and challenges for integrating adaptation and mitigation in tropical agriculture

Addressing the global challenges of climate change, food security, and poverty alleviation requires enhancing the adaptive capacity and mitigation potential of agricultural landscapes across the tropics. However, adaptation and mitigation activities tend to be approached separately due to a variety of technical, political, financial, and socioeconomic constraints. Many tropical agricultural systems can provide both mitigation and adaptation benefits if they are designed and managed appropriately and if the larger landscape context is considered. Many of the activities needed for adaptation and mitigation in tropical agricultural landscapes are the same needed for sustainable agriculture more generally, but thinking at the landscape scale opens a new dimension for achieving synergies. Intentional integration of adaptation and

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mitigation activities in agricultural landscapes offers significant benefits that go beyond the scope of climate change to food security, biodiversity conservation, and poverty alleviation. However, achieving these objectives will require transformative changes in current policies, institutional arrangements, and funding mechanisms to foster broad-scale adoption of climate-smart approaches in agricultural landscapes.

Agriculture lies at the crossroads of climate-change mitigation and adaptation efforts. The agricultural sector is currently responsible for an estimated 13.7% of global greenhouse gas (GHG) emissions (Tubiello et al. 2013) and is also a key driver of deforestation which contributes an additional 7–14% of global emissions (Harris et al. 2012; Hosonuma et al. 2012). At the same time, climate change will have significant negative impacts on many agricultural communities, particularly smallholders and poor farmers who have limited capacity to adapt to adverse shocks, further exacerbating global poverty and food insecurity (Howden et al. 2007; Morton 2007). Thus, both mitigation efforts to reduce GHG emissions and adaptation measures to maintain crop yields are of global significance.

Achieving significant progress on both mitigation and adaptation in the agricultural sector will contribute to the success of several multiple international policy initiatives. Mitigation is critical for meeting the overall goal of the United Nations Framework Convention on Climate Change (UNFCCC) to stabilize greenhouse gas concentrations in the atmosphere (United Nations 1992) and, in particular, for reducing greenhouse gas emissions from deforestation and degradation (i.e., through REDD+; Wollenberg et al. 2011). Adaptation in agriculture is necessary for meeting the Millennium Development Goals established by the United Nations (http://www.un.org/millenniumgoals/), especially those on eradicating extreme poverty and hunger (Sanchez and Swaminathan 2005). The Aichi Targets of the Convention on Biological Diversity (a set of targets developed for reducing the loss of biodiversity at the global level; CBD 2011) also acknowledge the importance of sustainable management of agriculture (Target 7) and climate change mitigation and adaptation efforts (Target 15). As a result, significant attention is now being paid to "climate-smart agriculture" which seeks to ensure the food security of a rapidly growing population while adapting to a changing climate and reducing GHG emissions (FAO 2013), as evidenced by recent policy conferences on Agriculture, Food Security, and Climate Change in the Netherlands (2010) and Vietnam (2012), the Commission on Sustainable Agriculture and Climate Change (Beddington et al. 2011), and new global initiatives on Climate Smart Agriculture (e.g., FAO 2010; World Bank 2011; Vermeulen et al. 2012).

Despite the growing recognition of the need to pursue mitigation and adaptation goals in agricultural systems and the current high profile of agriculture and climate change in international policy discussions, most adaptation and mitigation efforts continue to be approached in isolation from each other. Pursuing these activities separately, however, limits the potential to take advantage of synergies and to minimize tradeoffs across actions designed for either adaptation or mitigation benefits. It also leads to potential inefficiencies in the use of funding, and prevents an integrated management approach to agricultural landscapes which could both address climate issues and ensure the provision of food, water, and other ecosystem services (Scherr et al. 2012; Sayer et al. 2013).

In this article we highlight the opportunities for obtaining synergies between adaptation and mitigation activities in tropical agricultural landscapes and explore how agricultural systems and landscapes can be designed and managed to achieve these synergies. We also identify some of the key scientific, policy, institutional, funding, and socioeconomic barriers to achieving these synergies, and provide preliminary insights into how these barriers can be overcome. We focus our discussion on tropical agricultural systems because these have a higher mitigation potential than temperate systems (Smith et al. 2008; Hillier et al. 2012), are highly vulnerable to climate change, and are crucial for global efforts to improve food security and alleviate poverty (FAO 2010; Wollenberg et al. 2012a).

Climate-change adaptation, mitigation, and potential tradeoffs

A growing body of literature addresses the management practices that can be used to enhance the adaptive capacity or mitigation potential of tropical agricultural systems (e.g., FAO 2010, 2013; Wollenberg et al. 2012b). Adaptation options include a wide set of approaches designed to reduce the vulnerability and enhance the adaptive capacity of agricultural systems to climate change. These options include engineering solutions that deal with climate-related risks, breeding for different environmental stresses, developing early warning systems, and establishing crop insurance systems. They also include a range of farm management practices (such as soil and water conservation practices, crop diversification, and improved tillage practices) that make agricultural systems more resilient to climate change, diversify farmer livelihoods and ensure the continued supply of ecosystem services (Howden et al. 2007).

Mitigation options for agriculture, in contrast, are generally divided into three broad categories of practices: (1) activities that increase carbon stocks above and below ground; (2) actions that reduce direct agricultural emissions (carbon dioxide, methane, nitrous oxides) anywhere in the lifecycle of agricultural production; and (3) actions that prevent the deforestation and degradation of high-carbon ecosystems to establish new agricultural areas (Smith et al. 2007; Wollenberg et al. 2012b).

When adaptation and mitigation goals are pursued separately in agricultural systems, as is often the case, tradeoffs may occur over different temporal or spatial scales (e.g., Rosenzweig and Tubiello 2007; Verchot et al. 2007; Smith and Olesen 2010). For example, efforts to promote agricultural productivity of individual farms by increasing the use of agrochemicals couldmaintain crop yields in the face of climate change, but result in greater overall GHG emissions (Kandji et al. 2006). Conversely, the promotion of fast-growing tree monocultures or biofuel crops for mitigation purposes may enhance carbon stocks, but potentially reduce water availability downstream and decrease the land available for agriculture (Huettner 2012).

The consideration of tradeoffs across multiple temporal and spatial scales is critical since some tradeoffs will manifest themselves immediately, while others may show a time lag. For example, the use of conservation agriculture (which consists of practices that minimize soil disturbance, maintain permanent soil cover, and diversify crop rotation (Hobbs 2007) often reduces agricultural yields over the short term (3–5 years) but results in greater productivity and carbon sequestration over the long-term (Rusinamhodzi et al. 2011).

Potential tradeoffs between adaptation and mitigation activities can often be minimized, and sometimes even avoided, through integrated landscape level planning, an approach that considers adaptation and mitigation goals along with other dimensions such as food security, biodiversity conservation, and poverty alleviation (Biesbroek et al. 2009; Sayer et al. 2013; Scherr et al. 2012). For example, projects that aim to sequester carbon in forest plantations can potentially minimize potential impacts on water and biodiversity by establishing diverse, multispecies plantations of native species, minimizing the use of heavy machinery and pesticides in plantation establishment and management, and locating plantations on degraded lands (Brockenhoff et al. 2008; Stickler et al. 2009).

Integrating adaptation and mitigation in tropical agriculture

Several management strategies hold particular promise for simultaneously achieving adaptation and mitigation benefits at the plot and farm scale (Table 1). For example, soil conservation practices and the use of conservation agriculture, such as the incorporation of

Table 1. Examples of agricultural practices and actions that can confer adaptation and/or mitigation benefits at the plot, farm and/or landscape scale.

Scale	Practices that primarily confer adaptation benefits	Practices that provide BOTH adaptation and mitigation benefits	Practices that primarily confer mitigation benefits
PLOT	• Use of new crop varieties or livestock breeds that are drought-tolerant, or bred for specific environmental stresses • Adjustments in irrigation practices and systems • Changes in timing of planting, pruning or harvesting • Adjustments in cropping sequence and timing of irrigation or application of fertilizers and pesticides • Changes in timing, duration, and location of animal grazing • Conservation of crop and livestock genetic diversity	• Integrated soil and water conservation efforts • Incorporation of organic fertilizers and cover crops • Reduce or zero tillage • Maintenance of crop residues • Breeding crop varieties for shade tolerance • Use of agroforestry	• Reduced or more efficient use of fertilizers and pesticides • Adjustments in the type of feed provided to cattle • Reduced frequency or extent of fires • Reduced or more efficient use of machinery and fossile fuels • Improved management of cultivated wetland rice areas to reduce methane emissions
FARM	• Changes in rotation or production systems • Improved water harvesting and retention through ponds, dams, etc. • Increased water use efficiency through improved irrigation practices • Conservation of agrobiodiversity • Use of seasonal and multiyear forecasting	• Diversification of crops and livestock systems on the farm • Soil conservation practices, including terracing and land contouring • Improved residue management and use of cover crops • Integrated nutrient management • Use of agroforestry • Use of silvopastoral systems (e.g., trees in pastures, live fences, fodder banks) • Appropriate animal rotation practices • Use of conservation agriculture (i.e., minimal soil disturbance, maintenance of mulches, use of crop rotations and intercropping, integrated pest management) • Use of multi cropping, intercropping, and crop rotations	• Reduced or more efficient use of agrochemicals • Planting of biofuels and trees for fuel wood • Planting of fast-growing tree plantations • Reduced used of machinery and fossile fuels • Generation of biogas from manure • Use of improved feeding practices for livestock
LANDSCAPE	• Maintenance of habitat connectivity to ensure pollination and pest control • Development of water collector systems, irrigation infrastructure and other engineering solutions to reduce risks of floods, water scarcity, and other climate-related risks • Targeted location of intensive livestock production within the landscape to reduce water contamination • Diversification of farmer income options	• Land-use planning at the landscape level for multiple objectives • Maintenance of landscape diversity–including a mosaic of agricultural land and natural habitat • Conservation and restoration of riparian areas within the agricultural landscape • Conservation and restoration of remaining forest habitat in the surrounding landscape–including formal and informal protected areas • Establishment of agroforestry and silvopastoral systems • Sustainable intensification of livestock production and crop production in some areas, to reduce pressure on fragile areas • Increase in the duration of fallow periods in shift and burn cultivation • Restoration of degraded fragile lands • Conservation and restoration of wetlands and peat lands • Reduce expansion of cropland into remaining natural habitat	• Planting of biofuel feedstock • Careful management of fires

crop residues, use of composts, and minimum tillage, can increase organic carbon in soils, improve soil moisture, and reduce erosion during extreme weather events (Hobbs 2007; Delgado et al. 2011). The incorporation of trees in farms through agroforestry systems increases soil carbon stocks and above-ground biomass, while providing shade for protection from rising temperatures, diversifying farmer income and reducing financial risk (e.g., Verchot et al. 2007; Matocha et al. 2012). Most of these "climate-smart" practices that address both adaptation and mitigation goals are already well known and promoted under the banners of Conservation Agriculture, Agroforestry, Sustainable Agriculture, Evergreen Agriculture, silvopastoral systems, sustainable land management, EcoAgriculture, or best-management practices (McNeely and Scherr 2003; Hobbs 2007; FAO 2010; Garrity et al. 2010), but wider adoption of these practices is needed.

In many cases, it is possible to enhance both the adaptive capacity and mitigation potential of different agricultural systems and landscapes by changing the suite of management practices used. In annual cropping systems, changes from conventional tillage practices and high agrochemical input to soil conservation practices can convert the system from one that either provides only adaptation or mitigation benefits or neither types of benefits, to one that provides both adaptation and mitigation benefits, for instance if more water is captured or if a permanent soil cover increases soil organic matter (Figure 1a). For example, the adoption of conservation agriculture can lead to significant increases in yields of maize, sorghum, wheat, and other crops (up to 20–120% higher than those in conventional agriculture; Kassam et al. 2009), due to increased soil fertility, nutrient availability, and water availability. In addition, these systems have been shown to have a higher adaptive capacity to climate change (particularly reduced vulnerability to drought) than conventional systems because their soils have higher infiltration rates and greater moisture-holding capacity; Kassam et al. 2009). These systems can also increase carbon sequestration at soils, albeit at a slow rate and not in all situations: Baker et al. (2007) estimated that crop rotation systems in conservation agriculture accumulated 11 tons of carbon per hectare after 9 years.

In perennial cropping systems, such as coffee or cocoa, the inclusion of a diverse, well-managed shade canopy and appropriate soil management practices can similarly confer both adaptation and mitigation benefits (Figure 1b). Maintaining a diverse shade canopy of multifunctional trees in cocoa systems helps maintain soil organic matter and soil fertility, improves the stability of cocoa production, diversifies farmer livelihoods by providing sources of timber, fruits and other non-timber products, and provides ecosystem services at the landscape level (Tscharntke et al. 2010; Somarriba and Beer 2011; Somarriba et al. 2013). Cocoa agroforestry systems also maintain high levels of plant biomass and soil carbon storage, providing mitigation benefits. For example, traditional cocoa agroforestry systems in Central America have 117 ± 47 Mg/ha of total carbon in the soil and above-ground biomass, and accumulate between 1.3 and 2.6 of Mg C/ha/year in above-ground biomass annually (Somarriba et al. 2013).

Conclusions

There are significant opportunities to pursue adaptation and mitigation goals simultaneously in tropical agriculture and to adopt integrated landscape approaches that contribute to climate-change goals, food security, ecosystem service provision, and other goals. While there is no one general formula for capturing synergies between adaptation and mitigation, their joint consideration in landscape planning, research, technical support, government policies, and funding mechanisms would significantly help to achieve this goal. A renewed and strengthened commitment to sustainable agriculture, conservation agriculture, agroforestry, and other best management practices for agriculture, as well as an increased focus on integrated landscape management, would help to promote tropical agricultural systems and landscapes that have enhanced adaptation and mitigation potential, while contributing to food security, poverty alleviation, and biodiversity conservation across the tropics.

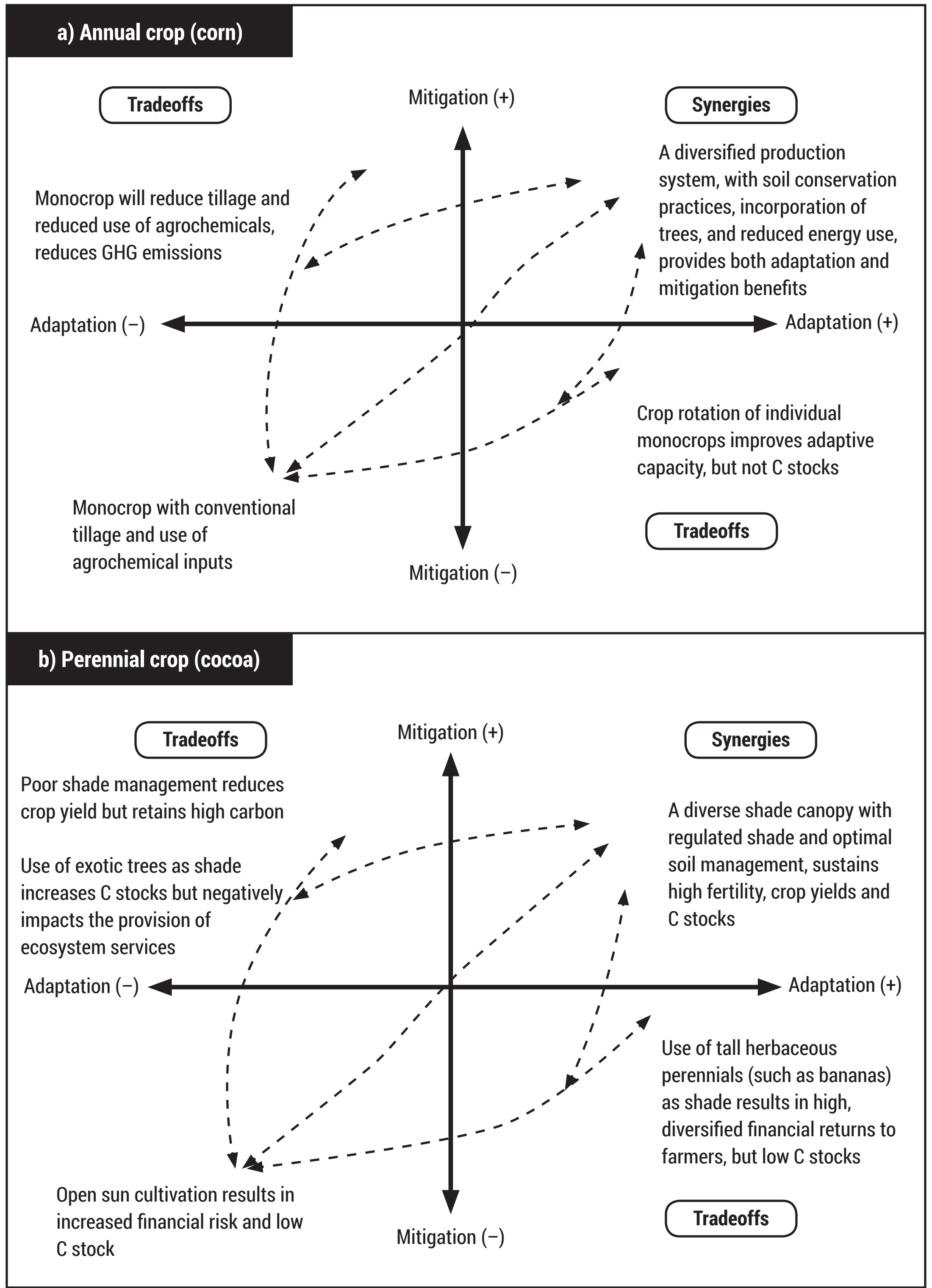

Figure 1. Diagrams showing how crop or livestock production systems can be managed to achieve synergies between adaptation and mitigation outcomes. In each diagram, the lower left quadrant indicates a system that provides minimal mitigation benefit and is not adapted to climate change. The upper left quadrant shows a system that has potentially high mitigation potential but little adaptive capacity, whereas the lower right quadrant shows a system that is adapted to climate change but releases significant green house gases or has low carbon stocks. The upper right quadrant indicates systems where both adaptation and mitigation benefits are achieved. Arrows illlustrate how changes in management can move the system from one state to another.

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Addressing synergies and trade-offs of climate-smart agriculture in agricultural landscapes

Supporting rural livelihoods through the landscape approach

The landscape approach is a promising concept for managing natural resources on the one hand and promoting rural livelihoods and addressing poverty reduction on the other. Poverty does not only originate at farm level. It stems from a combination of different factors, such as access to land and water resources and rights of use over their use, the accessibility of markets and services, and policy constraints.

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Making the sustainable livelihoods of local communities the centre piece of each landscape intervention is crucial. Practical experience in the past 30 years indicates that land and forest management to protect natural resources needs to take the needs of local people into consideration. For example, efforts to manage forests for conservation are likely to fail if local people do not benefit (e.g. through ecotourism) and have no other livelihood options than to encroach on forest land and convert it to other uses.

A landscape approach should involve all relevant stakeholders in land use decision making. This includes all farmers and stakeholders that depend on their landscapes. This principle is at the core of sustainable livelihood approaches focusing on poverty reduction interventions that empower the poor to build on their own opportunities and support their access to assets which form part of the wider landscape. Such assets include (i) human capital with skills, knowledge, health and ability to work; (ii) social capital with social resources, including informal networks, membership of formalized groups and relationships of trust that facilitate co-operation; (iii) natural capital with natural resources such as land, soil, water, forests and fisheries; (iv) physical capital including basic infrastructure, such as roads, water and sanitation, schools, information and communication technology; (v) on-farm capital, including tools and equipment; and (vi) financial capital including savings, credit, and income from employment, trade and remittances.

People with more assets are more likely to have greater livelihood options and can pursue their goals. Policies and institutions can influence the access to such assets, helping rural communities to stabilize or even enhance their livelihoods. A strong asset base is particularly important when people and their livelihoods are exposed and become more vulnerable to shocks or seasonal changes, which are expected to increase with climate change.

Addressing climate change with a landscape approach

Increased droughts, floods, heavy rains or other adverse climatic conditions will have negative impacts on people's lives. A strong asset base helps to buffer these impacts. It is an essential pre-requisite for establishing resilient livelihoods and strongly contributes to the adaptive capacity of rural communities.

Adaptive capacity applies to both human systems and natural ones, referring to "their ability to adapt, i.e. to adjust to climate change, including to climate variability and extremes; prevent or moderate potential damages; take advantage of opportunities; or cope with the consequences" (Kuriakose et al. 2009, p.9). The greater biodiversity found in managed heterogeneous landscapes is better able to buffer disturbances and maintain ecosystem services.

Land use systems and landscapes need to protect and produce a variety of different ecosystem services simultaneously to be resilient and adapt to a changing climate.

By taking a landscape approach and applying climate-smart agriculture, there are many ways of increasing mitigation and adaptation opportunities on the farm, in the community and throughout the ecosystem while sustainably increasing and intensifying productivity. Below is a list of activities that can help accomplish this:

- Conserving valuable ecosystems, such as wetlands and peat lands, which perform important regulatory services and constitute very large carbon sinks, should be given special attention and integrated in a multifunctional landscape and land use system. Production systems and ecosystems with a high degree of agricultural biodiversity can produce more biomass compared to monocultures and increase carbon sequestration in biomass and soils (Tilman et al. 2006; Frison et al. 2011). The increased biomass can also enrich soil fertility and improved water retention, leading to greater resilience to climate extremes.
- The conservation and regeneration of trees and restoration of degraded forests will also increase carbon stocks and may reduce the pressure on adjacent natural ecosystems, leading to a decline in emissions. An increased diversity of trees allows for more overall biodiversity in the landscape. It also creates and favourable light and moisture conditions and contributes to the regeneration of soils nutrients which makes the forest more resilient.
- Similarly, trees on farms or agroforestry systems can contribute to mitigating climate change as they tend to sequester greater carbon quantities than agricultural systems without trees. The trees have important functions, including shading crops, erosion control and nutrient cycling and can prevent crop destruction act by acting as buffers against storms. By providing a means for diversifying incomes, the trees provide a type of insurance if there are crop failures.
- Similarly, holistic management of grassland ecosystems and controlled grazing allows for the regeneration of degraded vegetation and soils. This creates a significant opportunity to sequester carbon in the soils and increase biomass and biodiversity through perennial grasses, shrubs and trees. Well managed grasslands provide other important benefits, such as increased water infiltration and retention and improved nutrient cycling.
- At the farm level, there are opportunities to increase productivity and carbon sequestration through conservation agriculture. Conservation agriculture combines zero or minimum tillage with crop rotations and cover crops or mulch. It enhances biomass by

Box 1. Post-disaster reconstruction in Pakistan using a watershed management approach

After a major earthquake in 2005, the Pakistan Earthquake Reconstruction and Rehabilitation Authority executed, in collaboration with FAO and with funding from the Swedish International Development Agency, a multisectoral project to implement the livelihood component of the rehabilitation plan. The control of hydrogeological hazards through collaborative watershed management at the village level, which was carried out in 17 watersheds was a key activity of the project. In each watershed, project implementation followed a landscape approach that combined landslide stabilization, improved natural resources management (particularly forests and trees) and the enhancement of agricultural production. In each watershed, the steps followed in project implementation were: watershed delineation; damage assessment and Participatory Rural Appraisal; the establishment of an integrated watershed management and land use plan; the implementation of prioritized activities; and capacity building. Field interventions included slope stabilization through check dams, retaining walls and bioengineering; forest regeneration; the establishment of tree nurseries and fruit tree orchards; the repair of irrigation channels and agricultural terraces; the improvement of livestock health; and kitchen gardening. Institutional innovations were introduced and tested. Traditionally, District Forest Offices (DFOs) planned and implemented forestry-related interventions. Now Watershed Management Committees enable communities to plan and prioritize their activities while the DFOs and other line agencies provide support in implementation.

By following the landscape and participatory approach, the project has built local resilience to cope with the impacts of climate change and natural disasters. Although floods in July 2010 again created significant damage in the region, communities supported by the project were well prepared to cope. Flood damage in the project watersheds was comparatively low because of the protective function of the introduced forests and trees. Thanks to the project, the communities have gained confidence in their own ideas and skills and feel responsible for the positive changes in their environment, agricultural innovations and improvements in their livelihoods. Through the Watershed Management Committees, they are now organized and have a voice to request technical assistance and support from line agencies and donors.

integrating trees and shrubs in and around the fields. Conservation agriculture increases tolerance to changes in temperature and rainfall occasioned by extreme climate events such as droughts or flooding.

- Careful management in livestock systems, which involves such practices as the circulation of nutrients and manure management, can reduce greenhouse gas emissions. Composting solid manures can produce useful organic inputs to increase soil fertility.
- By integrating different energy production options , including fuel wood production, biogas and solar energy, into the farming system greenhouse gas emissions can be reduced and decrease pressure on forests. Integrated food-energy systems tend to be relatively well-adapted to climatic variability because of their diversity and flexibility, especially when soil and water conservation, water harvesting and agroforestry are integrated into the overall system.
- Integrated aquaculture-agriculture offers diversification that comes from integrating crops, vegetables, livestock, trees and fish and can impart stability in production, efficiency in resource use, lower energy use and conservation of the environment. This is achieved by the adoption of agro-industrial technologies (such as gasification or anaerobic digestion) that allows maximum utilization of all by-products, and encourages recycling and economic utilization of residues.
- The cumulative effects of many farms employing such practices across the landscape are significant.

Synergies and trade-offs among different land uses and elements of landscapes

There are many examples of concrete interactions between different elements within landscapes. Sustainably managed landscapes with a mosaic of different land uses can be the foundation of a well-functioning ecosystem with a high biodiversity. In such landscapes, species are more likely to complement each other and better occupy the area over time and space (Loreau et al. 2003). The interaction and migration of species across different habitats and the spillover of organisms from undisturbed habitats, such as natural forests, to agricultural fields often has beneficial effects. For example, there is much evidence that in structurally complex landscapes natural pest control is higher and crop damage is lower than in less complex landscapes (Thies and Tscharntke 1999).

To optimize these multiple benefits, the trade-offs among different options must to be considered carefully. In many cases, the economic value of environmental services and external costs (environmental damages) and the direct or indirect benefit for land user groups tend to be underestimated. According to estimates, the vast array of ecosystem services that provide clean water for people have a net value of 4500 USD/ha/year in developed economies and 50–400 USD/ha/year in developing economies (Smith et al. 2006). Entrepreneurship and innovation can play an important role in tackling trade-offs between development and environment. They also generate positive externalities that can be employed to promote social empowerment. As such, private investment and entrepreneurship can ensure financial sustainability after upfront public sector investments have ended. For this reason, public-private partnerships are an important element in sustaining the social and cultural aspects of sustainability. Among other things, these partnerships can help return decision-making powers to farmers and contribute to ‘green growth’.

The concept of ‘green economy’, strongly advocated at the recent United Nations Conference on Sustainable Development in Rio de Janeiro (UNCSD 2012), provides many options for the private sector to embark on initiatives that promote low-carbon growth and are based on an efficient use of natural resources and social inclusion (UNEP 2011). With regards to agriculture, green growth involves increasing food security (in terms of availability, access, stability and utilization) while using less natural resources (FAO 2011b).

The landscape approach supporting the adoption of climate-smart agriculture

The outcomes and messages of the Seventeenth Session of the Commission on Sustainable Development (CSD 17) of May 2009, the First Global Conference on Agriculture, Food Security and Climate Change in The Hague in November 2010 and the RIO+20 United Nations Conference on Sustainable Development in June 2012 (UNCSD 2012) raised the profile of agriculture and related land uses in climate change discussions. The meetings acknowledged the special importance of the land-based sectors for increasing agricultural productivity; safeguarding important environmental services, such as water regulation, pollination and biodiversity and climate regulation, including reduced emissions and increased sequestration; and improving livelihoods and food security. To achieve the needed levels of growth an integrated landscape approach is required to manage the diversity of land uses across the landscape, as well as the interactions of the different land uses and components. Among the different land uses, there will be synergies and trade-offs and these need to be carefully evaluated and managed. Concerted efforts are required to manage the synergies and trade-offs between building the resilience of the ecosystems and livelihoods and reducing greenhouse gas emissions and other environmental impacts. Climate-smart agriculture integrates efforts to increase food production sustainably and optimize productivity with efforts to strengthen the resilience to climate change and variability and reduce agriculture’s contribution to climate change (FAO 2011c). Numerous experiences and best practises that can contribute to reaching the objective of climate-smart agriculture already exist and are well tested and are mentioned. These practices are vital for producing food, feed, fibre and energy, supporting food security, building resilience to climate change and other shocks, and mitigating climate change. These practices, which tap into the synergies between mitigation and adaptation, and support and restore the multiple functions and dynamic nature of agricultural systems and landscapes, should be scaled up to landscape level and further replicated.

Climate-smart agriculture is applicable to multiple levels. It covers practices and technologies at the field and farm level and involves working with communities over a much wider area, such as watersheds and ecosystems. Although many examples already exist of successes and benefits of climate-smart practices, there is still work to be done to improve technologies, policies and institutions to move from single objective production to the implementation of the types of multiple objective systems needed today. The breakthrough towards a broad application of climate-smart natural resources management will require a change in our thinking about agricultural production and in the related institutional structures that will make this transformation a reality. Building and restoring the locally-adapted

capacity for governance over resources and landscapes, enhancing social organization, and improving infrastructure and support services are among basic requirements for bringing about the desired results.

We already have a good understanding on how agriculture can be part of the solution to climate change and build the needs of adaptive capacity in agricultural systems and landscapes. The need for transition to climate-resilient, low-emitting production systems involves all land management systems in a given landscape. Climate-smart agricultural measures and policies have to be seen as key components of national regional and local climate change strategies. The recognition of the multiple dimensions and purposes of natural resource use and management and the interactions between human land use, management practices and natural resources require greater consistency across all land use sectors where implementation of climate-smart agriculture should play a critical role.

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Source: Mainstreaming climate-smart agriculture into a broader landscape approach

Background paper for the Second Global Conference on Agriculture, Food Security and Climate Change

September 3-7, 2012

By: Food and Agriculture Organization of the United Nations

Multiple benefit approaches building climate resilience alongside other benefits

Multiple benefit approaches emphasize more than just climate change benefits. They manage competing land-use systems at the landscape level, while at the same time reducing poverty, enhancing biodiversity, increasing yields and lowering greenhouse gas emissions. In many cases they are implemented as packages at the farm level. Taken together, they are examples of what is referred to as sustainable land management, sustainable land and water management, landscape approaches and watershed management, conservation agriculture, and rangeland management. Often, they also embrace the technique of integrated pest management and by

This article was repackaged from a previously published IFAD article entitled *Climate-smart smallholder agriculture: What's different?* by Elwyn Grainger-Jones and Per Rydén. Refer to the source box towards the end of this article for a complete reference to the original article.

design they are integrated systems of plant nutrient management. These approaches are knowledge-intensive and heterogeneous. They need to be adapted to local circumstances, requiring significant knowledge support at a time when extension services are often lacking the resources required to support smallholder farmers and farmers in marginal areas.

The following table provides a brief menu of some of the interventions being implemented or likely to be implemented in IFAD-supported programmes. These are described according to key areas for smallholder adaptation to climate change, but all activities typically generate multiple benefits. It is important to note that they are provided solely as examples, since communities are the principal drivers of investment options. The list does not include the potentially larger set of actions at the policy level to support and stimulate the uptake of these ground-level activities.

Greater demand for multiple benefits from policies and investment in rural areas is likely to create new demands for evidence, metrics and monitoring. The yield impacts of the sustainable agriculture approaches discussed above have been well documented. Less well documented, although scientifically intuitive, are the impacts on emissions, soil health, biodiversity and climate resilience. Many case studies have been developed, although there is scope for greater synthesis to document the multiple benefits of such approaches. This may be required if smallholders are to successfully make the case for a greater share of current and future environment (and climate) finance; for instance, further technical groundwork will be needed on the measurement and metrics of emissions impacts of diverse approaches.

Examples of multiple-benefit responses to adaptation challenges

Adaptation challenges	Potential ground-level multiple-benefit investments
1. Reduce yield losses associated with climate impacts through improved land management and climate-resilient agricultural practices	• Monitoring current climate change impacts and predicting future trends in downscaling and communicating weather and climate information to local communities for agricultural planning purposes, and in changing crop varieties and/or crop calendars to empower smallholder farmers to better contend with variability in rainfall and temperature • Identifying and promoting crop varieties that are heat, drought and salt tolerant, including wild varieties with high nutritional value • Optimizing land-use systems (e.g. shift to 'crop-for drop' from yield-per-hectare systems) to maximize sustainable yield under increasing climatic variability • Scaling up sustainable land management practices to the landscape level to improve hydrogeologic functions, soil nutrient replenishment, habitat heterogeneity, floral and faunal diversity, moderation of microclimate, and reduction in pest infestations and soil salinity as a means of improving the overall agricultural production context • Rehabilitating natural systems to protect agriculture in coastal areas against climate risks such as storm surges, e.g. mangrove, coastal wetland and sand dune rehabilitation, coral reef restoration • Recovering, documenting, disseminating and replicating traditional knowledge based on natural resource management and farmer-generated innovations suitable for promoting adaptation and healthier ecosystems

Examples of multiple-benefit responses to adaptation challenges.... contd.

Adaptation challenges	Potential ground-level multiple-benefit investments
2. Increase availability and efficiency of water use for smallholder agriculture production and processing	• Undertaking analyses of water use and distribution at the landscape level in light of changing trends in rainfall patterns to inform the design of sustainable agricultural production and processing systems • Using integrated water-resource management to maintain and improve the healthy functioning of watersheds and to build resilience to climate change by combining watershed management with resilience-oriented land-use planning, climate-proof infrastructure, water users associations, water recycling and grey water use • Adopting a range of water-harvesting techniques such as low-cost groundwater recharge methods, water-use-efficient irrigation systems and climate-proofed medium-sized reservoirs • Implementing flood management through catchment source control to reduce peak discharges, using mini-dams and levees that are designed to contend with rainfall of a higher intensity and longer duration
3. Increase institutional capacity for adaptation at local and national levels	• Building the capacity of local institutions to adapt to climate change and adopt agroecological farming models, including the capacity to identify and address agricultural systems that are simply not viable under conditions of climate change and will require farming system shifts • Building expertise in agricultural research that is climate-change-oriented and in the provision of advisory and extension services • Undertaking gender-differentiated vulnerability and risk assessments, assessing current livelihood systems and understanding smallholder farmers' own adaptation responses in order to formulate scaled-up adaptation management options • Developing user-friendly data management systems and intersectoral coordination mechanisms (at national and local levels) for synergistic programme and project development and implementation in which responses to climate impacts have been harmonized across a range of sectors • Increasing the capacity to develop policy frameworks that are resilient to climate change and equipped with climate change triggers to activate adaptation response mechanisms • Strengthening health, food security and agriculture linkages in light of climate impacts, e.g. through a focus on nutrition • Improving regulatory systems to provide incentives for the uptake of adaptation responses and climate-smart sustainable land management • Improving the clarity of governance structures dealing with climate-change related matters that have an impact on the rural sector and establishing linkages between relevant local and national government institutions • Improving access to 'green markets' and creating incentives for climate-resilient products (e.g. rooibos tea) • Promoting South-South cooperation in exchanging knowledge on responses to climate change and, where relevant, developing transboundary initiatives that foster uptake of adaptation measures

Examples of multiple-benefit responses to adaptation challenges.... contd.

Adaptation challenges	Potential ground-level multiple-benefit investments
4. Strengthen disaster risk reduction at the community level	• Establishing early warning systems and disaster mitigation plans • Strengthening community-based disaster preparedness (social networks and safety nets) and response and rehabilitation mechanisms • Establishing climate-proof storage for community seed, food and forage • Turning disasters into opportunities to undertake climate-smart land-use zoning, and formulating and rolling out ecosystem restoration plans for post-disaster scenarios • Developing a climate risk-management strategy based on financial assets (such as savings, mutualization, insurance), promoting in particular the development of climate risk insurance
5. Promote technologies that reduce vulnerability of rural livelihoods and increase efficiency along agricultural value chains	• Developing downscaled data-gathering and management systems to improve decision-making and project design • Using geographic information systems to better understand and monitor landscape use • Exploring the use of improved seed varieties that can withstand flooding, drought and salinity, and developing in situ conservation of genetic resources (e.g. through seed banks) • Enhancing the use of information communication technologies in disseminating best practice in adaptation (short videos of sustainable land management and adaptation techniques) and mobile phone early warning systems • Testing prototype agricultural production systems that can withstand a range of climate-change-induced stresses in diverse agroecological zones, combined with a shift from extensive low-nutrition agricultural productive systems to intensive high-nutrition production systems
6. Ensure that rural infrastructure is climate-resilient	• Assessing climate change impacts on existing key agricultural infrastructure in order to refine design and engineering specifications to keep pace with future impacts • Raising crop stores and livestock housing above new flood levels • Building/retrofitting rural infrastructure to cope with climate-related risks such as water shortages and extreme weather events, e.g. dykes, breakwaters, submersible roads • Strengthening food security systems by improving storage and marketing facilities • Preventing the pollution of water supplies

Source: Climate-smart smallholder agriculture: What's different?
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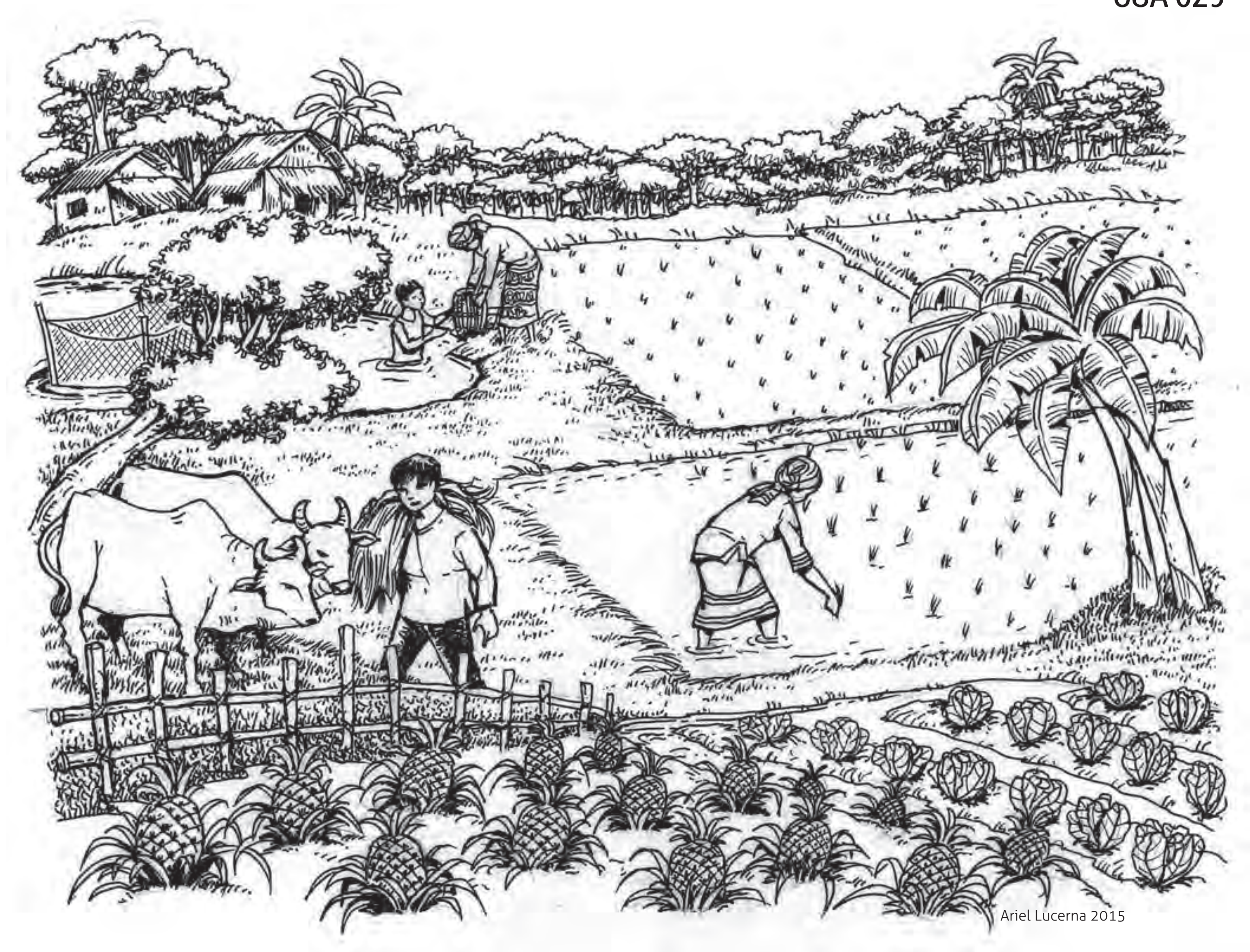
Ariel Lucerna 2015

Where the land is greener:

Experiences contributing to sustainable land management

There are numerous positive experiences that contribute to sustainable land management — but this wealth of information is often not tapped, and commonly not even recognised. The World Overview of Conservation Approaches and Technologies (WOCAT) is a network and a methodology with the aim of sharing this valuable knowledge to improve livelihoods and the environment. Forty-two promising case studies were recently documented and analysed in a global overview book entitled 'where the land is greener' (WOCAT 2007), from which a consolidated list of policy points were drawn. This paper highlights some of these conclusions and policy points.

This article was repackaged from a previously published source entitled *Where the Land is Greener – Experiences Contributing to Sustainable Land Management* by Gudrun Schwilch, Hanspeter Liniger, Daniel Danano, Sudibya Kanti Khisa and William Critchley. Refer to the source box towards the end of this article for a complete reference to the original publication which contains the case studies and an indepth analysis through editors note published in 2007. These materials are being included in this sourcebook to draw attention to early efforts to document conservation technologies, most of which remain relevant today.

Background

The productivity of some 23 per cent of all usable land has been affected by human-induced soil degradation (UNEP 1997; Oldeman et al. 1990). Land users and soil and water conservation (SWC) specialists have a wealth of knowledge related to land management, improvement of soil fertility and protection of soil, water and vegetation resources, but the implementation of good practice still lags far behind: much knowledge about potential improvements is poorly documented and thus inaccessible both to other practitioners, and to those concerned with analysis, evaluation and dissemination. It was in this context that WOCAT was founded, in 1992, as a global network of SWC specialists, and with the aim of developing standardized tools for documenting, monitoring and evaluating SWC know-how and for disseminating it around the globe as a means of facilitating the exchange of experience. The database developed by WOCAT currently comprises datasets on 400 technologies and 260 approaches from over 40 countries, of which a subset of 190 technologies and 110 approaches are quality assured. Approximately 60 participating institutions meet annually, help to further develop the WOCAT methodology and network and conduct relevant research and training. They use self-evaluation in a joint effort with land users and researchers, and use SWC/SLM knowledge to make informed choices and influence policy.

From case studies to policy points

A compilation of 42 case studies, each describing a technical intervention (from traditional to innovative) in conjunction with a specific implementation approach (from project-promoted to spontaneously), has recently been published by WOCAT (2007), including a thorough analysis, solid conclusions and practical policy guidance. The analysis, enriched with knowledge of additional technologies and approaches, provides an insight into what underpins successful and/or widespread examples of natural resource management (NRM). It seeks to present a balanced critique, drawing on a wide range of examples, regions and land use systems.

The policy points deriving from these case studies reflect 'what' needs to be done to improve how money is being spent for improved land management and environmental protection, whilst improving the livelihoods of people in rural areas, rather than 'how' it can be achieved. Similar compilations have been produced at national level in Bangladesh and Ethiopia.

Soil and water conservation technologies—measures on various land use types and their impacts

Most SWC efforts have been made on cropland, and out of 42 technologies presented by WOCAT (2007), 36 are applied under rainfed conditions. Although poor irrigation practices and associated problems (e.g. salinisation) are widespread, measures for the sustainable use of irrigated land have not yet been adequately identified and documented. Only three cases are concerned with grazing land, and none with forest land. Despite the fact that the livelihoods of many rural people are based on livestock production and are often located in dry and marginal areas, SWC investments are insufficient, in these locations and often hindered by common property problems.

An overarching lesson is that prevention or mitigation are generally more cost-effective than rehabilitation. Other lessons learned can usefully be broken down by agro-ecological characteristics: in dry areas, investments in water harvesting and improved water use efficiency, combined with improved soil fertility management, should be emphasised to increase production, reduce the risk of crop failure, and lower the demand for irrigation water. In humid areas, long-term investments are required to maintain soil fertility and minimize on-site and off-site damage caused by soil erosion. Conservation measures leading to increased soil organic matter and thus carbon sequestration represent a win-win scenario: land resources are improved at the local level and at the same time a contribution is made to the mitigation of climate change.

A useful distinction can be made among agronomic, vegetative, structural and management measures. Agronomic measures, such as manuring / composting and crop rotation can easily be integrated into daily farming activities. They are not perceived as an additional 'conservation' burden, as they require comparatively low inputs and have a direct impact on crop productivity. Many vegetative measures are both traditional and multipurpose: agroforestry systems have conservation effects through e.g. ground cover, but can also be directly useful for production of fodder, fruits, nuts, fuelwood and timber, as well as for nitrogen fixation. Successful SWC associated with intensive and diverse smallholder agroforestry systems can in some areas result in 'more people, more trees'. Where vegetative measures compete with crops for nutrients, water and land, and are not directly productive (e.g. vetiver grass lines and windbreaks), the vegetation needs to be carefully managed, e.g. through pruning. Structures are hardly ever adequate on their own, and commonly involve high investment costs. Thus, terraces on steep slopes need to be complemented by agronomic and vegetative measures. The greater cost-effectiveness of agronomic and vegetative measures and their additional benefits such as soil cover, soil structure and soil fertility improvement means that they should be given priority over structures. Management measures are especially important on grazing land (e.g. area closure). More than half the technologies presented by WOCAT (2007) are combinations of various agronomic, vegetative, structural and/or management measures. Whether overlapping, or spaced over a catchment/landscape, or over time, such measures tend to be the most versatile and the most effective in difficult situations. They support each other and often address multiple degradation types.

Policy conclusions

- More sustainable land management (SLM) can increase income, improve food security, and sustain natural resource productivity at local level; at global and national levels it can safeguard natural resources and ecosystem services, preserve cultural heritage, and contribute positively where water scarcity, land use conflicts, climate change, and biodiversity conservation are concerned.
- There are no 'silver bullet' ways of improving SLM. The ecological, social and economic causes of degradation need to be understood, and technologies need to be responsive to change.
- Concerted efforts to standardise documentation and evaluation of SLM technologies such as soil and water conservation (SWC) are needed, especially in the light of the billions of dollars spent annually on implementation.
- SLM/SWC approaches also require long-term commitment from research and policy organisations, in order to allow joint learning, monitoring and evaluation, and adaptation.
- More attention should be given to local innovations rather than focusing on project-based implementation of standard technologies.
- Prevention and mitigation of degradation are less costly and should be prioritised over rehabilitation.
- Further research is needed to quantify and value ecological, social and economic impacts of SWC, both on-site and off-site, and to develop methods for the valuation of ecosystem services.
- The enabling environment to support SWC investments should build on people's and nature's capacity, not overlooking indirect measures such as credit, market opportunities, legislation and security of land use rights.
- SWC may require heavy investment costs beyond the capacity of land users, but direct material incentives should only be considered to overcome initial investments and where environmental improvements and social benefits are likely to be realised only in the long term.

Soil and water conservation approaches — enabling and stimulating implementation

The documented case studies span a wide variety of different approaches: about two thirds of the technologies are implemented under a project, while the others are based on local traditional systems, and individual initiatives. Two thirds of the case studies relate to small-scale farming systems. 31% are associated with subsistence farming. There are a number of preconditions for success, including a focus on production aspects, security of access, long-term commitment and investment, participation of stakeholders, capacity building, and a willingness to draw on human resources: people's knowledge, creativity and initiative. The analyses made clear that local innovation and traditional systems offer at least as much potential as project-based SWC experimentation. SWC requires long-term commitment from national and international implementation and research institutions. Here a clear strategy and partnership alliances are needed to sustain results beyond the project life-span.

Three quarters of the 'SWC' cases analysed are directly related to increasing productivity and/or farm income, with conservation coming in as a spin-off, so it is essential to identify the scope for conservation in parallel with economically-driven change. Generally, it is assumed that SWC implies high investment, but there are examples of conservation agriculture which are both cost- and timesaving. However, costs and benefits are difficult for contributors to assess and may not be free from bias.

The establishment of an enabling environment is extremely important in the promotion of SWC, emphasising the 'pull' (motivation), e.g. better marketing channels or secure access to land, as well as the 'push' (enforcement), e.g. SWC legislation and national campaigns. Opportunities need to be seized that connect SWC with emerging environmental priorities – especially carbon sequestration (by increasing soil organic matter), biodiversity, conservation, watershed management and ecosystem service provision. Ways of recognition and payment for these services need to be further explored to justify SWC investments. Fair prices, certification, and labelling schemes for products can stimulate conservation. But the case studies showed that direct material incentives (money, inputs, etc.) should be used carefully – in 15 out of the 20 project-based case studies direct incentives did not play a major role. At best they offer a step-up to impoverished farmers, at worst they can distort prioritiesand by creating dependency and pseudo-interest in SWC. Training and extension advice are key elements of project-based approaches. There has been a general switch to more participation, devolution of powers, and less authoritarianism. But increased empowerment requires enhanced capacity. Investment in training and extension to support the capacity of land users and other local and national stakeholders must be a priority to adapt better to changing environmental, social and economic conditions, and to stimulate innovation. Local innovation and farmer-to-farmer extension have proven to be wide-spread, effective and appropriate strategies, which are not yet sufficiently recognized.

Soil and Water conservation technologies in action

In Kenya, "more people mean more trees". Against all the conventional wisdom, small scale farmers around Mount Kenya are planting a multi-purpose tree called the "Silky Oak" (Grevillea robusta), often along farm boundaries or on terrace risers, occasionally scattered in cropland. The ancient forest may have disappeared, but a new agroforestry landscape has been created.

In Australia, sugar cane farmers have started harvesting their cane without burning it and simultaneously spreading the separated residues, leaving a dense mulch cover, the so called green cane trash blanket. The advantages: less greenhouse gas produced, improved biodiversity in the soil, and eroded sediment no longer pollutes the Great Barrier Reef.

Source: WOCAT (2007)

Conclusions

The WOCAT (2007) review of selected SWC technologies and approaches reaches a number of general policy conclusions which will require local adaptation: some are new; others confirm what is already known but deserves re-emphasising.

Knowledge management — the basis for decision support

Concerted efforts to standardise documentation and evaluation of SWC technologies and approaches are justified, given the billions of dollars spent annually on implementation. Scattered knowledge about SWC needs to be identified, documented and assessed via a systematic review process that involves the joint efforts of land users, technical specialists and researchers. Once documented, experiences with SWC need to be made widely accessible so that land users, advisors and planners can review 'baskets' of options. New SWC efforts should build on existing knowledge from within a location itself or, alternatively, from similar conditions and environments elsewhere. There is need for a standardised methodology—like the WOCAT tools—to facilitate comprehensive data collection, knowledge management and dissemination.

Monitoring and evaluation—improve SWC and justify investments

Monitoring and evaluation (M&E), especially of the technical efficiency and cost-effectiveness of SWC technologies and approaches, are weak spots. Likewise, traditional land use systems and local land management innovations are rarely documented or assessed for their conservation effectiveness. M&E can lead to important changes and modifications in approaches and technologies: nearly all (17 of 20) of the project-based approaches presented by WOCAT (2007) reported changes as a result of M&E. SLM/SWC initiatives are constantly evolving. Land users have to be involved in M&E: their judgement of the pros and cons of SWC interventions is crucial. More investment in training and capacity building is needed for M&E, for impact assessment, and to improve skills in knowledge management including the dissemination and use of information. Although several countries and regions have land degradation maps, mapping of SWC efforts and areas under SLM has been badly neglected. Such mapping can enhance awareness of what has been achieved and where, as well as justifying further investments and guiding decision-making.

Natural resource conservation approaches and technologies in Bangladesh

Bangladesh Conservation Approaches and Technologies (BANCAT, www.bangcat.org) was established in 2004. It is a network of SWC and other NRM specialists. BANCAT aims to achieve healthy hill ecosystems with well-managed natural resources linked to improved and secure livelihoods of the people of Chittagong Hill Tracts (CHT) in particular and Bangladesh in general. Despite growing population pressure on the limited hilly land resources in CHT accompanied by land ownership conflicts and a non-conducive national policy regime, CHT farmers have managed to improve their farming and livelihood conditions by adopting appropriate (traditional and new) conservation farming approaches and technologies. However, most of their knowledge remains undocumented and so has not been shared. Through an integrated approach using WOCAT tools, BANCAT aims to explore, evaluate and document SWC approaches and technologies, to facilitate research and education, to build capacity for SWC documentation and dissemination including quality assurance, and to bridge the information gap between policy-makers and SWC practitioners. It also helps SWC and NRM specialists to share knowledge and assists them in their search for SLM technologies and approaches. An overview of 39 technologies and approaches for BANCAT (Khisa et al. 2006) is expected to contribute towards bridging important gaps in knowledge.

BANCAT is also committed to contribute to the implementation of UN Conventions, such as those on desertification, climate change, andbiodiversity. BANCAT also works closely with WOCAT, HIMCAT (Himalayan Conservation Approaches and Technologies) and WASWC (World Association of Soil and Water Conservation) in pursuit of the Millennium Development Goals.

Complexity and knowledge gaps—the role of research

The problems of land degradation are complex and so are the solutions. Effective SWC depends on suitable technologies and approaches, and on flexibility and responsiveness to changing complex ecological and socio-economic environments. It is therefore important to understand the ecological, social and economic causes of degradation, to analyse what works and why, and how to modify and adapt particular technologies and approaches to locally specific circumstances and opportunities. Valuation of the ecological, social and economic impacts of SWC, both on- and off-site, is urgently necessary, as is the development of methods for the valuation of ecosystem services. This, and the further development of tools and methods for knowledge exchange and improved decision support, should be undertaken jointly with land users, scientists from different disciplines and decision-makers.

WOCAT and Sustainable Land Management in Ethiopia

Ethiopia is one of the countries in sub-Saharan Africa most seriously threatened by land degradation, and addressing this problem has been consistently identified as a major priority in virtually all national strategies and policy documents. Land degradation has posed an acute challenge to rural livelihoods and threatens the integrity and function of ecosystems of national and global significance. There is a close relationship between land degradation, drought, crop failure and malnutrition in Ethiopia.

The government of Ethiopia, with donor assistance, has recently designed a Country Partnership Program for Sustainable Land Management in Ethiopia (CPPSLM) with the aim of conserving and restoring landscapes of national and global ecologic, economic and social importance through the adoption of sustainable land management policies, practices and technologies. CPPSLM adopted WOCAT tools for its knowledge management system. Its components include: institutional strengthening, scaling up of best practices, developing a land monitoring system and establishing program coordination and management. The scaling-up of best practices will be based on a compilation done by EthioCAT (Ethiopian Overview of Conservation Approaches and Technologies) of 52 technologies and 28 approaches common in Ethiopia. Emphasis is placed on cost-benefit analysis, especially given the time needed for a return on investments.

SWC technologies and approaches—improving impact and supporting implementation

It is commonly assumed that enough is known about SWC technologies, and that it is just a question of applying them. However, adaptations to technologies and approaches are often necessary to match them to locally specific social, political, economic and environmental circumstances and opportunities. Measures often need to be combined to become cost-effective. Evidence has shown that adaptations of local innovations often perform better and are more readily integrated into a land use system than introduced 'standard' SWC technologies. Direct material incentives have a limited role and good enabling environments have to be in place (e.g. land policy).

Overall policy—investing in SWC for ecosystem, society and the economy

The cases presented by WOCAT (2007) demonstrate the value of investing in rural areas. Ecologically, SWC technologies can effectively combat land degradation. But a majority of agricultural land is still not sufficiently protected, and SWC needs to spread further. Beyond soil erosion and water loss, potential ecosystem benefits include regulation of watershed hydrological functions—assuring base flows, reducing floods and purifying water supplies—as well as carbon sequestration, and preservation of biodiversity.

Socially, SWC helps to improve food security and reduce poverty, both at household and national levels. It can also support social learning and interaction, build community spirit, preserve cultural heritage, and counterbalance migration to cities.

Economically, SWC pays back investments made by land users, communities or governments. Agricultural production is safeguarded and enhanced for smallscale subsistence and large-scale commercial farmers alike, as well as for livestock keepers. Furthermore, the considerable off-site benefits from SWC can often be an economic justification in themselves.

From a policy perspective, investment in rural areas, natural resource management and sustainable land use is a local concern, a national interest, and a global obligation. SLM has to be a core pillar of any rural development and agricultural policy, or investments in poverty reduction based on improving agriculture's performance may fail. Stronger representation of SLM concerns in national high-level policy documents such as Poverty Reduction Strategy Papers needs to be achieved (Bojö and Reddy 2003). Given the political dimensions of SLM (Hurni et al 2006), global environmental problems require international coordination. A major challenge (and opportunity) at all levels will be to learn from properly documented and evaluated experiences on SLM and SWC and apply this learning in current and future efforts towards sustainable management of natural resources.

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Source: Where the Land is Greener – Experiences Contributing to Sustainable Land Management

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Climate change and biodiversity for food and agriculture

As climate changes, the value of biodiversity for food and agriculture will increase. Genetic resources are the living material that local communities, researchers and breeders use to adapt food and agricultural production to changing needs. Maintaining and using this reservoir of genetic diversity will be the foundation for coping with climate change.

Genetic erosion

Climate change will be an important driver of genetic erosion in the future. It will both threaten the survival of individual species and affect the way different elements of biodiversity interact in food and agriculture ecosystems. These interactions provide "services", such as pollination, soil fertilization and the natural biological control of plant and animal

This was drawn from an article entitled *Climate Change and Biodiversity for Food and Agriculture* by Food and Agriculture Organization of the United Nations. Refer to the source box towards the end of this article for a complete reference to the original article.

Key Facts

- The 2005 Millennium Ecosystem Assessment estimates that by the end of this century, climate change will be the main cause of biodiversity loss.
- The Intergovernmental Panel on Climate Change asserts that roughly 20 to 30 percent of species it has assessed are likely to be at increasingly high risk of extinction as global mean temperature exceeds pre-industrial levels by 2 to 3° C.
- Many livestock breeds cannot be genetically improved fast enough to adapt to climate change.
- Coping mechanisms based on local biodiversity are particularly important for the most vulnerable people, who have little access to formal employment, land or market opportunities.

pests and diseases, that are essential for food production. Smallholder and subsistence farmers and pastoralists will be the hardest hit by disruptions in these services.

This irreversible loss of biodiversity will have serious consequences for global food security. If coordinated efforts are taken at the national and international levels, biodiversity can be conserved and harnessed to help food and agriculture adapt to climate change.

What is at stake?

The Intergovernmental Panel on Climate Change reports that a significant number of species will be at risk of extinction as the global mean temperature increases. Of particular concern are relatives of major crops surviving in the wild. Crop wild relatives are already under severe threat due to habitat loss and environmental degradation. Climate change, which may make their remaining habitats unsuitable for their survival, may drive them to extinction. Research by the Consultative Group on International Agricultural Research based on distribution models (see maps overleaf) of wild relatives of three staple crops of the poor—peanuts, cowpea and potato—suggests that by 2055 16–22 percent of wild species will be threatened by extinction.

In some areas, food is still gathered from the wild. Genetic erosion represents an immediate threat to the well-being of rural communities. Loss of genetic diversity can also have serious long-term consequences globally. Plant wild relatives may contain the genes for traits that could be used to breed new crop and forest varieties that can meet the challenges of climate change.

Livestock breeds and fish with limited geographic distribution may also face the risk of extinction because of climate change and the increased frequency of natural disaster (droughts, flooding, major storms) associated with it. For example, tilapia, a fish species vital to the food security of millions, originated in areas of Africa where the impact of climate change is expected to be extreme. Loss of genetic diversity in tilapia subspecies, many of which can only be found in African lakes and rivers, would decrease the breeding options for this species worldwide.

Climate change adaptation and mitigation

Researchers and local communities need to reach into the planet's vast genetic reservoir to breed new plants and animals that will thrive in a warmer world and meet the food requirements of an expanding population. For many small-scale and subsistence farmers, adapting to changing conditions may be difficult. The rate of climate change suggests that in many instances locally available genetic diversity will be unable to adapt quickly enough to survive. In these cases, collecting and conserving the threatened diversity will be crucial. Crop varieties or species better

suited to new growing conditions may need to be introduced. In the livestock sector, this sort of substitution has already begun. In some drought-prone areas of Africa, pastoralists are switching to raising camels instead of sheep and goats.

The increased use of biodiversity for food and agriculture, particularly soil microorganisms, also has the potential to mitigate climate change by reducing the accumulation of greenhouse gases in the atmosphere. Harnessing local biodiversity can maintain the health of forests and the fertility of agricultural soils, both of which are important carbon sinks. It can also reduce the need for nitrogen-based fertilizers, a major source of greenhouse gases, and other energy-intensive commercial inputs.

Decline of a strategic resource

Projections suggest that by 2055 climate change will cause the dramatic decline of the important genetic resource wild vigna (related to the African staple cowpea, an important and inexpensive source of protein) from its current distribution and genetic diversity.
(Source: A. Jarvis et al.)

What is to be done?

There is an urgent need to determine the distribution of biodiversity for food and agriculture both in the wild and in the fields and assess its vulnerability to climate change. Matching biodiversity distribution mapping with different climate change scenarios is a basic requirement for countries to develop conservation strategies. Information is also needed about the biodiversity held in national and international gene banks. The potential to harness this biodiversity to cope with climate change remains untapped, largely due to a lack of information on the characteristics of the genetic diversity conserved and their performance in the field. Global information systems that can store and manage this data and make it accessible to researchers, breeders and farmers are essential.

This information and analysis needs to be integrated into future reports of the Intergovernmental Panel on Climate Change. And the panel's climate change data and projections need to be incorporated into FAO's global biodiversity assessments.

Farmers at the forefront

Rural communities have the largest stake in developing strategies to cope with climate change, and understanding how they are currently using biodiversity to cope with climate change should be the basis for future actions. Men and women farmers, pastoralists and fisherfolk and their local institutions need to be given access to information about climate change and the ways locally available biodiversity can help them adapt.

Access to agricultural biodiversity will determine whether a given strategy is feasible. Governments must ensure that rural communities have access to the biodiversity they need. Especially important will be global exchange mechanisms that can ensure every country has access to genetic resources for food and agriculture and that can guarantee the fair and equitable sharing of the benefits arising out of their use.

Source: Climate Change and Biodiversity for Food and Agriculture

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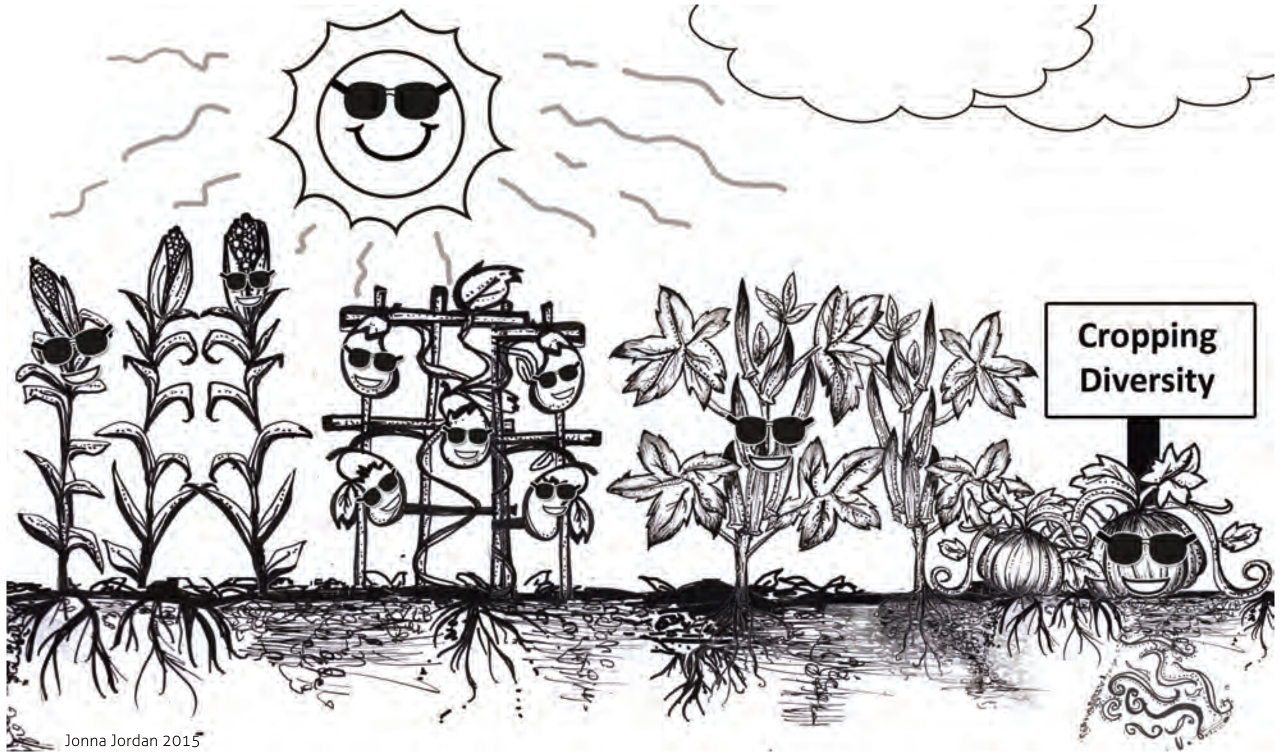

Biodiversity and organic agriculture: An example of sustainable use of biodiversity

Organic agriculture is a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. (Codex Alimentarius Commission 1999)

Biodiversity from organic agriculture

Organic farmers are both custodians and users of biodiversity at all levels:

- **Gene level:** endemic and locally adapted seeds and breeds are preferred for their greater resistance to diseases and resilience to climatic stress;
- **Species level:** diverse combinations of plants and animals optimize nutrient and energy cycling for agricultural production; and
- **Ecosystem level:** the maintenance of natural areas within and around organic fields and the absence of chemical inputs create habitats suitable for wildlife. Reliance on natural pest control methods maintains species diversity and avoids the emergence of pests resistant to chemical controls.

This article was drawn from previously published material entitled *Biodiversity and Organic Agriculture: An Example of Sustainable Use of Biodiversity* by of Nadia El-Hage Scialabba. Refer to the source box towards the end of this article for a complete reference to the original article.

Biodiversity for organic agriculture

Organic agriculture manages locally available resources to optimize competition for food and space between different plant and animal species. The manipulation of the temporal and spatial distribution of biodiversity is the main productive "input" of organic farmers. By refraining from using mineral fertilizers, synthetic pesticides, pharmaceuticals and genetically modified seeds and breeds, biodiversity is relied upon to maintain soil fertility and to prevent pests and diseases.

Organic agriculture and soil ecosystems

Organic practices such as crop rotations and associations, cover crops, organic fertilizers and minimum tillage increase the density and richness of indigenous invertebrates, specialized endangered soil species, beneficial arthropods, earthworms, symbionts and microbes (FiBL 2000). Such soil biodiversity enhances soil forming and conditioning, recycles nutrients, stabilizes soils against erosion and floods, detoxifies ecosystems and contributes to the carbon sequestration potential of soils.

Organic agriculture and agro-ecosystems

Rotation of crops in organic systems functions as a tool for pest management and soil fertility. This, together with inter-cropping, integrated crop-tree-animal systems, the use of traditional and underutilized food and fodder species and the creation of habitats attracts pest enemies and pollinators and decreases the risk of crop failure across the agroecosystem. Agricultural biodiversity is conserved and developed through the regeneration of locally adapted landraces and the improvement of genotypes of many plant varieties and animal races near extinction (IFOAM 2000).

Organic agriculture and nature conservation

The maintenance of vegetation adjacent to crops and plant corridors are common in organic systems, providing alternative food and refuge for many insect predators, wild flora, birds and other wildlife. The absence of pesticide drifts and herbicides and onfarm integration of natural habitats (e.g. productive perennial plants, hedgerows) and other structures (e.g. stepping stones and corridors for migrating species) attract new or re-colonizing species to the area. Ultimately, the diversity of landscape and wildlife attracts people in the form of ecotourism, providing an important source of off-farm income (McNeely and Scherr 2001).

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Climate change and transboundary pests and diseases

Countries spend large sums of money to eradicate and control animal and plant diseases and pests. Climate change is now creating favourable conditions for animal and plant pests and diseases in new areas as well as changing the way they are transmitted.

Charting the change

While there is clear evidence that climate change is altering the distribution of animal and plant pests and diseases, the full effects are difficult to predict. Changes in temperature, moisture and atmospheric gases can fuel growth and generation rates of plants, fungi and insects, altering the interactions between pests, their natural enemies and their hosts. Changes in land cover, such as deforestation or desertification, can make remaining plants and animals increasingly vulnerable to pests and diseases. While new pests and diseases have regularly emerged throughout history, climate change is now throwing any number of unknowns into the equation.

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Some of the most dramatic effects of climate change on animal pests and diseases are likely to be seen among arthropod insects, like mosquitoes, midges, ticks, fleas and sandflies, and the viruses they carry. With changes in temperatures and humidity levels, the populations of these insects may expand their geographic range, and expose animals and humans to diseases to which they have no natural immunity.

Other climate changes can create more opportunities for vector-borne diseases. In pastoral areas, for instance, drier conditions may mean fewer watering holes, which will increase the interaction between domesticated livestock and wildlife. Increased interaction between cattle and wildebeest in East Africa could lead to a serious outbreak of malignant catarrhal fever, a highly fatal disease for cattle, since all wildebeest carry the fever virus.

Aquatic animals are also vulnerable to emerging climate-related diseases, particularly since their ecosystems are so fragile and water is such an effective disease carrier. A fungal disease called the epizootic ulcerative syndrome recently expanded to infect fish in southern Africa due in large part to increases in temperature and rainfall levels.

Protecting food and farmers

Pests and diseases have historically affected food production either directly through losses in food crops and animal production, or indirectly through lost profits from insufficient cash crop yields. Today, these losses are being exacerbated by the changing climate and its increasing volatility, threatening food security and rural livelihoods across the globe.

Developing countries with a high reliance on agriculture are the most vulnerable to today's changing patterns of pests and disease. Hundreds of millions of smallholder farmers depend solely on agriculture and aquaculture for their survival. As rural farmers struggle to produce food, poor people in nearby urban areas are left to contend with less availability in addition to higher food prices. National economies will also suffer as new pests and diseases either reduce agricultural products' access to international markets or incur higher costs associated with inspection, treatment and compliance.

Plant pests, which include insects, pathogens and weeds, continue to be one of the biggest constraints to food and agricultural production. Fruit flies, for instance, cause extensive damage to fruit and vegetable production and, as the globe's temperatures continue to increase, are finding more areas to call home. Controlling such pests often requires the use of pesticides, which can have serious side effects on human health and the environment. This is particularly true for poor rural people, who cannot afford to use the less toxic compounds or to own proper application or safety equipment.

Climate change may also play a role in food safety. A growing number of pests and diseases could lead to higher and even unsafe levels of pesticide residue and veterinary drugs in local food supplies. And changes in rainfall, temperature and relative humidity can readily contaminate foods like groundnuts, wheat, maize, rice and coffee with fungi that produce potentially fatal mycotoxins.

Strengthening cooperation and early detection

Climate change is a global problem that is affecting every single country. Global cooperation therefore is required to respond to it.

However, given the nature of plant pests and animal diseases, more localized or regionalized strategies will be needed to be effective. Investments in early control and detection systems, including border inspections, will be key to avoid the higher costs of eradication and management. Coordinated research, including programmes related to climate change and food security from the Consultative Group on International Agricultural Research, will be needed to improve the range of options available to countries.

International trade and traffic spread transboundary animal and plant pests and diseases and alien invasive aquatic species. Countries take measures to keep new diseases and pests out. Such measures may hinder the free flow of goods and should therefore be scientifically justified and be as limited as possible in their effects on trade. New uncertainties and possibilities of introduction caused by climate change have the potential to increase these regulations and their effect on trade.

The containment of some pests and diseases may not be feasible because, for example, they are spreading too fast. New farming practices, different crops and animal breeds, and integrated pest management principles must be developed to help stem their spread. Governments may need to consider the introduction of biological control agents or new pest- or disease-resistant crops and breeds.

Governments need to strengthen national animal and plant health services as a top priority. They need to focus on basic sciences, such as taxonomy, modeling, population ecology and epidemiology. Governments should also consider how to better consolidate and organize their national animal and plant health services since they are often fragmented across different ministries and agencies.

Disease-causing insect moves north

Bluetongue disease is a devastating infection of ruminants that has historically been confined to southern Europe along the Mediterranean. However, since 1998, northern Europe has had increasingly warm weather and some midges that carry the virus that causes bluetongue have moved north. Changing temperatures have also allowed new, more populous insect species to transmit the disease, which has enhanced its spread. Bluetongue's biggest impact may be felt among cattle farmers; many countries will not accept meat exports from countries where bluetongue occurs.

Source: Climate Change and Transboundary Pests and Diseases

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Livestock and climate change

The effects of climate change on livestock and fisheries

The possible effects of climate change on food production are not limited to crops and agricultural production. Climate change will have far-reaching consequences for dairy, meat and wool production, mainly arising from its impact on grassland and rangeland productivity. Heat distress suffered by animals will reduce the rate of animal feed intake and result in poor growth performance (Rowlinson 2008). Lack of water and increased frequency of drought in certain countries will lead to a loss of resources. Consequently, as exemplified by many African countries, existing food insecurity and conflict over scarce resources will be exacerbated. The following sections provide an overview of the effects of climate change on both livestock and fisheries.

This article was drawn from previously published materials entitled *Livestock and climate change* by Antonio Rota, Chiara Calvosa, Delgermaa Chuluunbaatar and Katiuscia Fara. Refer to the source box towards the end of this article for a complete reference to the original article.

The effects of climate change on livestock

In pastoral and agropastoral systems, livestock is a key asset for poor people, fulfilling multiple economic, social and risk management functions. The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are affecting livestock production systems, such as rapid population and economic growth, rising demand for food (including livestock) and products,[1] conflict over scarce resources (land tenure, water, biofuels, etc). For rural communities, losing livestock assets could trigger a collapse into chronic poverty and have a lasting effect on livelihoods.

The direct effects of climate change will include, for example, higher temperatures and changing rainfall patterns, which could translate into the increased spread of existing vector-borne diseases and macroparasites, accompanied by the emergence and circulation of new diseases. In some areas, climate change could also generate new transmission models.

These effects will be evident in both developed and developing countries, but the pressure will be greatest on developing countries because of their lack of resources, knowledge, veterinary and extension services, and research technology development.[2]

Some of the indirect effects will be brought about by, for example, changes in feed resources linked to the carrying capacity of rangelands, the buffering abilities of ecosystems, intensified desertification processes, increased scarcity of water resources, decreased grain production. Other indirect effects will be linked to the expected shortage of feed arising from the increasingly competitive demands of food, feed and fuel production, and land use systems. In a recent paper, Thornton et al. (2008) examined some of the direct and indirect impacts of climate change on livestock and livestock systems. These are summarized in Table 1.

Meeting the challenge: adaptation and mitigation livestock strategies

Livestock can play an important role in both mitigation and adaptation. Mitigation measures could include technical and management options in order to reduce GHG emissions from livestock, accompanied by the integration of livestock into broader environmental services. As described in the section below, livestock has the potential to support the adaptation efforts of the poor. In general, livestock is more resistant to climate change than crops because of its mobility and access to feed. However, it is important to remember that the capacity of local communities to adapt to climate change and mitigate its impacts will also depend on their socio-economic and environmental conditions, and on the resources they have available.

[1] Globally, livestock products contribute approximately 30 per cent of the protein in human diets (Gill and Smith 2008), and this contribution is only expected to increase (FAO Stats).

[2] The effects of rising temperatures vary, depending on when and where they occur. A rise in temperature during the winter months can reduce the cold stress experienced by livestock remaining outside. Warmer weather reduces the amount of energy required to feed the animals and keep them in heated facilities (FAO 2007b).

Table 1. Direct and indirect impacts of climate change on livestock and livestock systems

Factor	Impacts
Water:	Water scarcity is increasing at an accelerated pace and affects between 1 and 2 billion people. Climate change will have a substantial effect on global water availability in the future. Not only will this affect livestock drinking water sources, but it will also have a bearing on livestock feed production systems and pasture yield.
Feeds:	Land use and systems changes As climate changes and becomes more variable, niches for different species alter. This may modify animal diets and compromise the ability of smallholders to manage feed deficits. Changes in the primary productivity of crops, forage and rangeland Effects will depend significantly on location, system and species. In C4 species, a rise in temperature to 30-35° C may increase the productivity of crops, fodder and pastures. In C3 plants, rising temperature has a similar effect, but increases in CO^2 levels will have a positive impact on the productivity of these crops. For food-feed crops, harvest indexes will change, as will the availability of energy that can be metabolized for dry season feeding. In semi-arid rangelands where the growing season is likely to contract, productivity is expected to decrease. Changes in species composition As temperature and CO^2 levels change, optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes. For example, higher CO^2 levels will affect the proportion of browse species. They are expected to expand as a result of increased growth and competition between each other. Legume species will also benefit from CO^2 increases and in tropical grasslands the mix between legumes and grasses could be altered. Quality of plant material Rising temperatures increase lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species. The resultant reduction in livestock production may have an effect on the food security and incomes of smallholders. Interactions between primary productivity and quality of grasslands will require modifications in the management of grazing systems to attain production objectives.
Biodiversity (genetics and breeding):	In some places there will be an acceleration in the loss of the genetic and cultural diversity already occurring in agriculture as a result of globalization. This loss will also be evident in crops and domestic animals. A 2.5° C rise in global temperature would determine major losses: between 20 and 30 per cent of all plant and animal species assessed could face a high risk of extinction. Ecosystems and species display a wide range of vulnerabilities to climate change, depending on the imminence of exposure to ecosystem-specific critical thresholds, but assessments of the effects of CO^2 fertilization and other processes are inconclusive. Local and rare breeds could be lost as a result of the impact of climate change and disease epidemics. Biodiversity loss has global health implications and many of the anticipated health risks driven by climate change will be attributable to a loss of genetic diversity.

Table 1 continued.

Factor	Impacts
Livestock (and human) health:	Vector-borne diseases could be affected by: (i) the expansion of vector populations into cooler areas (in higher altitude areas: malaria and livestock tick-borne diseases) or into more temperate zones (such as bluetongue disease in northern Europe); and (ii) changes in rainfall pattern during wetter years, which could also lead to expanding vector populations and large-scale outbreaks of disease (e.g. Rift Valley fever virus in East Africa). Temperature and humidity variations could have a significant effect on helminth infections. Trypanotolerance, an adaptive trait which has developed over the course of millennia in sub-humid zones of West Africa, could be lost, thus leading to a greater risk of disease in the future. Changes in crop and livestock practices could produce effects on the distribution and impact of malaria in many systems, and schistosomiasis and lymphatic filariasis in irrigated systems. Heat-related mortality and morbidity could increase.

Adapted from Thornton et al.,2008.

Source: Livestock and climate change
Livestock Thematic Papers - Tools for Project Design

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The potential for mitigation of GHGs in livestock production systems

The Committee on Climate Change (2008) adopted an approach of identifying three routes for abatement potential in relation to the Greenhouse Gas (GHG) emissions by agriculture:

- lifestyle change (i.e. less reliance on products with a high carbon cost associated with their production);
- changing farming practice; and
- using new technologies.

These are discussed in turn on the next page.

This article was drawn from previously published materials entitled *The potential for mitigation of GHGs in livestock production systems* by Margaret Gill, Pete Smith, and J. M. Wilkinson. Refer to the source box towards the end of this article for a complete reference to the original article.

Lifestyle change

Attention has been drawn to the high 'cost' of livestock products in terms of broader environmental impacts for the last decade or more (e.g. Brown 1997; Steinfeld et al., 2006). In recent times, the focus has been on the 'cost' in terms of GHG emissions as discussed earlier. At a global level, these concerns have not stemmed the increasing demand for livestock products, especially in those countries where meat and milk have until recently made relatively small contributions to total daily human food consumption (Steinfeld et al. 2006). Global consumption of meat is projected to increase from 201 Mt in 1997 to 334 Mt in 2020. Similarly, global production of milk is projected to increase from 445 to 661 Mt in the same period (Delgado 2005).

A relatively high proportion of these increases reflect trends in China and India, which mirror the trends in food consumption in the dietary changes which occurred in Western Europe, North America and Australasia in the first half of the 20th century (Grigg 1999). When forecasting future trends, therefore, it is worth noting both the impact of health messages (links between animal fats and diseases in humans) and the divergence between regions as noted by Grigg (1999). In the UK, animal protein accounted for a steady percentage of total dietary protein between 1993 and 2003 (Figure 1; FAOSTAT 2008) compared with the increase in percentage of animal protein consumed in China over the same time period.

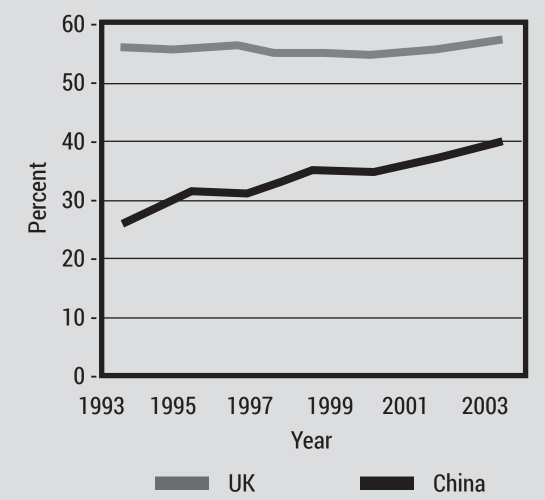

Figure 1. Trends in animal protein consumption as a percentage (%) as total protein consumption in UK and China from 1993 to 2003 (FAOSTAT 2008).

Table 1. Percentage contribution to total meat production and consumption by different livestock species in the UK and their relative contributions (%) to greenhouse gas (GHG) emissions.

	Production	Consumption	GHG Emissions
Poultry	48	43	26
Pigs	21	28	16
Cattle	22	20	27
Sheep	10	9	21

Figures for meat consumption by species are given in Table 1, showing the dominance of monogastric species in terms of both production and consumption. Interestingly, while poultry meat forms a smaller percentage of meat production at a global level (31% compared to 48%), the ratio of production of ruminant to monogastric meat is similar to that in the UK (FAOSTAT 2008). In recent years, the number of ruminant livestock in the UK has been declining in response to changes in the Common Agricultural Policy (change from payments per head of livestock to payments on an area basis). This contributes to decreasing GHG emissions appearing in the UK inventory, but unless demand changes, the impact on global GHGs will depend on the carbon cost associated with the production system used to produce the imports to replace domestic consumption.

The typical UK diet is higher in saturated fat and sugar than recommended by official dietary guidelines and Arnoult (2006) undertook a modelling exercise to explore what changes in dietary components would best achieve the recommended diet. If consumers were to comply strictly with UK health recommendations, and at the same time minimize changes in their dietary preferences to do so, there would be decreases in the consumption of milk and milk products (particularly cheese), carcass meat, confectionery and soft drinks (Arnoult 2006). The result would be a decrease in the demand for livestock products, especially those with relatively high concentrations of saturated fat. This suggests that a decrease in production would be more likely in terms of dairy systems than meat production. The relatively stable consumption of animal products in recent years, despite health recommendations and lobbying by environmental groups suggests, however, that such a change is unlikely unless the costs of livestock products to the consumer are considerably increased.

Another way in which demand might be influenced, however, is through the reduction in food waste. There are strong policy incentives for moving to a 'zero-waste' society, which could help to decrease the current level (5% to 13%) of avoidable or partially avoidable food waste associated with livestock products (DEFRA 2008).

Changing farming practice

As with food waste, there is significant scope for decreasing the 'waste' associated with low on-farm productivity. Improvements in production efficiency all have the potential to decrease the carbon footprint of livestock production as illustrated in Figure 2. The basic principle throughout is that animals emit methane (ruminants) and produce manure which results in release of further methane and N_2O (all livestock) from the day they are born to the day they die: all of these emissions will be attributed to production. Emissions per unit of product can thus be decreased either by increasing the efficiency of the animal production system itself or by direct action on the route of emissions (e.g. through feed or by using new technologies such as methane or N_2O inhibitors). The potential mitigation which is still to be captured from improved productivity is obviously dependent on the basal level of productivity and is greater in developing countries as illustrated by Smith et al. (2008). The impacts of improved genetics, fertility and health all contribute to reducing the number of animals required to meet a steady demand for animal products, while the issues of feed, manure and grazing management are rather more complex and will be considered separately below.

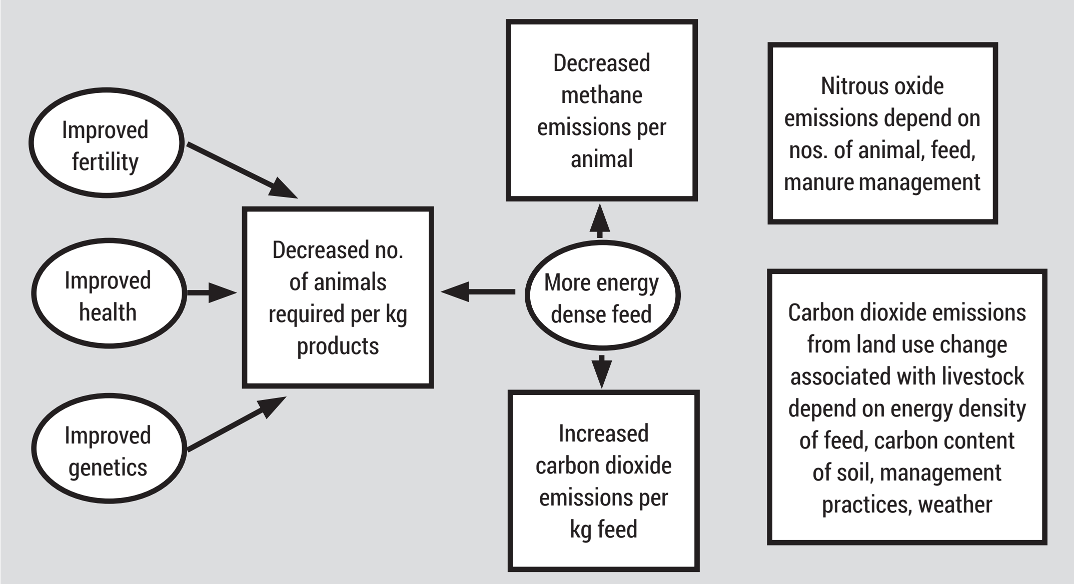

Figure 2. Routes for impact of management technology interventions designed to improve productivity on greenhouse gas emissions from livestock where total emissions = (no. of animals times emissions per animal plus associated emissions from manure and land management.

Improved productivity through breeding, fertility and health. In the case of the UK dairy herd, the same quantity of milk was produced in 2005 from a million fewer animals than 20 years earlier, because average annual milk yield per cow increased from 5000 to almost 7000 l, a 2% increase per year. Garnsworthy (2004) calculated that the total methane (t/year) associated with the production of one million litres of milk from cows producing 9000 l/cow per year was just over 50% of the methane which would be associated with cows producing 6000 l/cow per year, taking into account the differing nutritional requirements and the concentrate intake and neutral detergent fibre concentration of the least cost ration formulated to meet the requirements. The same principles apply to whether the increased productivity is due to health, fertility or breeding, provided that the emissions associated with feeds are accounted for.

Livestock breeding

Recent modelling studies in the UK by Genesis-Faraday (Genesis-Faraday Partnership 2008; Jones et al. 2008) have indicated that past selection for production traits such as growth rate, milk production, fertility and efficiency of feed conversion has resulted in decreases in GHG production per unit of livestock product of about 1% per annum. These have been greatest in those species in which the greatest genetic gains have been achieved—poultry, dairy cows and pigs. The authors predicted that the trends are likely to continue in future at least at the rate achieved over the past 20 years. Genetic improvement is continuous and cumulative, and the technology is readily transferable via selected germplasm. There are economic incentives to use improved breeding stock, so reductions in GHGs are likely to be achieved without major changes in current farming practices—at least in nonruminants. The adoption of routine determinations of efficiency of feed conversion in ruminants could produce acceleration in both rate of genetic gain and reduction in GHG emissions per unit of product, provided that the information was incorporated in indices of breeding value.

Livestock fertility

While breeding has resulted in increases in milk yield per cow year-on-year, fertility has decreased. Garnsworthy (2004) estimated the impact of fertility on GHG emissions, through the construction of a model, which linked changes in fertility to herd structure, number of replacements, milk yield and nutrient requirements to GHG emissions. He reported that replacements contributed up to 27% of the methane and 15% of the ammonia attributed to dairy cows in the UK. Improving fertility would lead to decreased numbers of replacements required, with a consequent significant decrease in GHG emissions.

Animal health

The impact of disease on livestock productivity is highly variable between countries dependent on the incidence of endemic diseases, and between years on the incidence of infectious diseases, particularly when these are associated with the culling of animals. Since the carbon costs are directly associated with the impacts on productivity, economic frameworks such as that developed by McInerney et al. (1992) could be used to explore the likely impacts of different diseases. An added complication for livestock disease, however, is that climate change is also likely to impact on the incidence of disease, as seen for example, in the recent incidence of Bluetongue virus in the UK (Gale et al. 2009).

Attention needs to be drawn to the distinction between decreasing numbers of livestock associated with increased productivity, and decreasing numbers in response to policy changes. In the former, similar levels of domestic demand can be met, while the latter situation may lead to increased imports, which may have higher or lower associated GHG emissions, depending on the relevant production systems.

Mitigation through management of feeding, manure and land use

Livestock feeds

One area that receives considerable attention (particularly from the media) is manipulation to decrease methane emissions from enteric fermentation. Research on methane was common in the 1960s when various ruminant researchers tried to decrease methane production as a means of achieving increased feed conversion ratios (unit of feed in: unit of product out), since eructation of methane represents a loss of energy to the animal. Both the amount of digestible nutrients ingested and the composition of the diet were found to be major factors governing methane production (Blaxter and Clapperton 1965). More recently, equations have been developed by Yates et al. (2000). These equations demonstrate that increasing the energy density of the diet (e.g. by increasing ratio of concentrates to forage) decreases methane production per unit of digestible energy ingested. Increasing energy density also increases productivity, thereby also contributing to decreased carbon per unit of product.

The composition of livestock diets can also affect the amount and ratios of nitrogenous components excreted in manure (Paul et al. 1998), providing another route by which livestock feed can influence GHG emissions. One recent study (Misselbrook et al. 2005) has looked at the potential of increasing the tannin level in diets to decrease the rate of release of N_2O, but the net benefit is likely to depend on the composition of the manure and the ambient conditions.

The different rations offered to livestock can change in composition and in efficiency of utilization in a number of ways, but with many individual feed components being imported, complexity will also be added by changes in the availability of ration components.

Manure management

One of the uncertainties associated with the potential benefits to net GHG emissions of increasing land under pasture, is the uncertainty associated with losses of N_2O from fertilizer or manure. The key principle is to maximize the uptake of nutrients by the pasture plants. Factors such as the amount of manure applied (Scholefield et al. 1993) and the intensity of grazing (Ryden et al. 1984) are known to influence nitrogen leaching and were included in a model developed by Hansen et al. (2000) to compare organic v. conventional farming. However, due to lack of data, such models are not yet at a stage of development though to be able to deal with all the processes involved.

Impact of land use

Smith et al. (2008) estimated the potential of a range of land management practices to mitigate GHG emissions, identifying restoration of organic soils, management of cropland and grassland as having particularly high potential, though there are issues associated with permanence and saturation of the carbon sink (Smith 2005). The key principles in this respect are to avoid loss of carbon from the soil and to manage the application of nutrients in fertilizers and manure to maximize uptake by plants. In terms of soil, the type of soil is closely associated with the amount of carbon it contains and there is a huge variability across the UK with Scotland holding around a half of the organic carbon content of soils in Great Britain (Bradley et al. 2005). Recent research has shown that there is little change in soil carbon under permanent pasture (Hopkins et al. 2008), with the major changes being related to changes in land use (Smith 2008). Soil monitoring networks exist across Europe, but they are unable to detect changes at a level of use to policy-makers (Saby et al. 2008). There is, therefore, considerable research activity in predicting changes in soil carbon in response to land-use change (e.g. ECOSSE; Smith et al. 2007c), but this knowledge is not yet at a stage at which it can be incorporated into the national inventory for the UK. The potential advantages in decreasing net carbon emissions of changing land use from arable to grass are thus challenging to estimate at the farm level, and cannot yet be captured in the metrics used by policy-makers. Thus while more land under pasture is a clear winner in terms of decreased GHG emissions from soil, grazing the grass leads to methane emissions, and the loss of arable land has implications for food security.

The potential for new technologies

Discussion in the previous section and in Figure 2 has highlighted the close relationship between opportunities to decrease GHG emissions from livestock and those to increase productivity. Many evolving technologies being developed to increase productivity will thus also have a beneficial effect in terms of the indirect contribution of livestock to GHG emissions. This section will concentrate on technologies that focus primarily on direct emissions, i.e. on decreasing the emission of methane and N_2O.

Methane

Attempts to find ways of inhibiting methane production in the rumen have been made for over 30 years (e.g. Czerkawski and Breckenridge 1975), with interest rekindled more recently, particularly in New Zealand where the large numbers of ruminants make a significant contribution to the country's GHG emissions (Judd et al. 1999).

Apparently significant successes in decreasing methane production have been achieved in experiments in vitro or in single animal feeding trials (e.g. Lopez et al. 1999; McGinn et al. 2004) but these have not proved to be robust when applied to a variety of feeding regimes and some methods such as the use of ionophores are banned in the European Union. Research is continuing in New Zealand using a variety of approaches co-ordinated through the Pastoral Greenhouse gas Research consortium (PGgRc 2009). Such research needs to adopt a systems approach, however, since Hindrichsen et al. (2006) reported a negative correlation between enteric methane production v. methane released from the slurry of cows offered forage-only diets compared to those offered forage supplemented with concentrates. The potential benefits to the cattle and sheep industries globally of finding a compound that would reduce methane production without decreasing productivity or increasing methane and N_2O emissions from manure and that could be applied in pastoral systems with low labour inputs are huge. The challenge is that ruminants evolved 40 million years ago with a pre-gastric digestion system to enable them to feed on cellulose, with methane produced as a by-product (Van Soest 1994) and there is no advantage per se to that ecosystem of avoiding methane production.

Nitrification inhibitors

Less attention has been paid over the years to technologies for controlling the emission of N_2O, since the benefits that would accrue at first inspection, appear to be purely environmental. However, nitrification inhibitors have been used in New Zealand to promote early season herbage growth (due to soil nitrogen retention over winter). Solving this problem should be easier than trying to adjust the ecological balance within the rumen and indeed research at the scale of individual urine patches has shown very significant reductions (PGgRc 2009). Inhibitors showing particular promise for inhibition in pasture-based systems are: dicyandiamide and 3,4-dimethylpyrazole phosphate.

Human nature dictates that there will always be more media interest in the potential large wins of new technologies to solve problems rather than in the more mundane approaches of improving management efficiencies, but the reality is that both approaches need to be pursued to deal with both the urgency and the scale of the need to reduce GHG emissions. If neither approach is shown to be delivering sufficient reductions from the livestock sector, the pressure to decrease meat consumption will continue to increase. However, such a pressure ignores another major challenge of the 21st century that of increasing the amount of food produced at a rate sufficient to meet the growing demand.

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Adaptation and mitigation strategies in the livestock sector

Livestock adaptation strategies

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. However, the expanding human population, urbanization, environmental degradation and increased consumption of animal source foods have rendered some of those coping mechanisms ineffective (Sidahmed 2008). In addition, changes brought about by global warming are likely to happen at such a speed that they will exceed the capacity of spontaneous adaptation of both human communities and animal species.

This article was repackaged from previously published materials entitled *Livestock and climate change* by Antonio Rota, Chiara Calvosa, Delgermaa Chuluunbaatar and Katiuscia Fara. Refer to the source box towards the end of this article for a complete reference to the original article.

The following have been identified by several experts (FAO 2008; Thornton et al. 2008; Sidahmed, 2008) as ways to increase adaptation in the livestock sector:

Production adjustments

Changes in livestock practices could include: (i) diversification, intensification and/or integration of pasture management, livestock and crop production; (ii) changing land use and irrigation; (iii) altering the timing of operations; (iv) conservation of nature and ecosystems; (v) modifying stock routings and distances; (vi) introducing mixed livestock farming systems, such as stall-fed systems and pasture grazing.

Breeding strategies

Many local breeds are already adapted to harsh living conditions. However, developing countries are usually characterized by a lack of technology in livestock breeding and agricultural programmes that might otherwise help to speed adaptation. Adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann 2008). Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds. If climate change is faster than natural selection, the risk to the survival and adaptation of the new breed is greater.

Institutional and policy changes

Removing or introducing subsidies, insurance systems, income diversification practices and establishing livestock early warning systems—as in the case of IFAD-supported interventions in Ethiopi, and other forecasting and crisis-preparedness systems—could benefit adaptation efforts.

Science and technology development

Working towards a better understanding of the impacts of climate change on livestock, developing new breeds and genetic types, improving animal health and enhancing water and soil management would support adaptation measures in the long term.

Capacity building for livestock keepers

There is a need to improve the capacity of livestock producers and herders to understand and deal with climate change increasing their awareness of global changes. In addition, training in agro-ecological technologies and practices for the production and conservation of fodder improves the supply of animal feed and reduces malnutrition and mortality in herds.

Livestock management systems

Efficient and affordable adaptation practices need to be developed for the rural poor who are unable to afford expensive adaptation technologies. These could include (i) provision of shade and water to reduce heat stress from increased temperature. Given current high energy prices, providing natural (low cost) shade instead of high cost air conditioning is more suitable for rural poor producers; (ii) reduction of livestock numbers—a lower number of more productive animals leads to more efficient production and lower GHG emissions from livestock production (Batima 2006); (iii) changes in livestock/herd composition (selection of large animals rather than small); (iv) improved management of water resources through the introduction of simple techniques for localized irrigation (e.g. drip and sprinkler irrigation), accompanied by infrastructure to harvest and store rainwater, such as tanks connected to the roofs of houses and small surface and underground dams.

Market responses

The agriculture market could be enhanced by, for example, the promotion of interregional trade and credit schemes.

Mitigation of livestock GHG emissions

Unmitigated climate change will, in the long term, exceed the capacity of natural and human systems to adapt. Given the magnitude of the challenge to reduce GHG concentrations in the atmosphere, it is imperative to receive the contribution of all sectors with significant mitigation potential. Agriculture is recognized as a sector with such potential, and farmers, herders, ranchers and other land users could and should be part of the solution. Therefore, it is important to identify mitigation measures that are easy to implement and cost effective in order to strengthen the capacity of local actors to adapt to climate change. The livestock production system contributes to global climate change directly through the production of GHG emissions, and indirectly through the destruction of biodiversity, the degradation of land, and water and air pollution. There are three main sources of GHG emissions in the livestock production system: the enteric fermentation of animals, manure (waste products) and production of feed and forage (field use) (Dourmad et al. 2008). Indirect sources of GHGs from livestock systems are mainly attributable to changes in land use and deforestation to create pasture land. For example, in the Amazon rainforest, 70 per cent of deforestation has taken place to create grazing land for livestock. In general, smallholder livestock systems have a smaller ecological footprint than large-scale industrialized livestock operations.

Mitigation of GHG emissions in the livestock sector can be achieved through various activities, including:

- Different animal feeding management.
- Manure management (collection, storage, spreading).
- Management of feed crop production.

The contribution the livestock sector can make to the reduction of emissions varies. Possible mitigation options include (FAO 2008b):

Selection of faster growing breeds

Improvements could be made to livestock efficiency in converting energy from feed into production and losses through waste products can be reduced. Increasing feed efficiency and improving the digestibility of feed intake are potential ways to reduce GHG emissions and maximize production and gross efficiency, as is lowering the number of heads. All livestock practices—such as genetics, nutrition, reproduction, health and dietary supplements and proper feeding (including grazing) management—that could result in improved feed efficiency need to be taken into account.

Improved feeding management

The composition of feed has some bearing on enteric fermentation and the emission of CH_4 from the rumen or hindgut (Dourmad et al. 2008). The volume of feed intake is related to the volume of waste product. The higher the proportion of concentrate in the diet, the lower the emissions of CH_4.

Better waste management

Improving the management of animal waste products through different mechanisms, such as the use of covered storage facilities, is also important. The level of GHG emissions from manure (CH_4, N_2O, and CH_4 from liquid manure) depends on the temperature and duration of storage. Long-term storage at high temperatures results in higher GHG emissions. In the case of ruminants, pasture grazing is an efficient way to reduce CH_4 emission from manure because no storage is necessary. It is possible not only to mitigate GHG emissions but also to create an opportunity for renewable energy.

Grazing management

One of the major GHG emission contributions from livestock production is from forage or feed crop production and related land use. Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from feed crop production. Animal grazing on pasture also helps reduce emissions attributable to animal manure storage. Introducing grass species and legumes into grazing lands can enhance carbon storage in soils.

Lowering livestock production and consumption

Lowering the consumption of meat and milk in areas with a high standard of living is a short-term response to GHG mitigation.

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Fisheries and aquaculture in our changing climate

Coastal communities, fishers, and fish farmers are already profoundly affected by climate change. Rising sea levels, acid oceans, droughts and floods are among the impacts of climate change. Oceans provide the very air, the oxygen we breathe, and climate change is altering the ancient balance between oceans and the atmosphere.

This policy brief highlights the key issues to ensure that decision makers and climate change negotiators are aware of and understand the changes and their impacts, and the opportunities for adaptation and mitigation in aquatic ecosystems, fisheries and aquaculture at the UNFCCC COP-15 in Copenhagen in December 2009 and in national and local responses to climate change. The brief also reflects the consensus of 19 concerned international and regional agencies.

This article was drawn from previously published materials entitled *Fisheries and aquaculture in our changing climate* by Food and Agriculture Organization of the United Nations. Refer to the source box towards the end of this article for a complete reference to the original article.

Fisheries, aquaculture and fish habitats are at risk in the developing world Deltas and estuaries are in the front line of climate change. For example, sea level rise and reduced river flows are causing increasing saltwater intrusion in the Mekong delta and threatening the viability of catfish aquaculture. This industry produces about 1 million tonnes per year, valued at $1 billion and provides over 150,000 livelihood opportunities, mostly for women.

The build-up of carbon dioxide and other greenhouse gases in our atmosphere is changing several of the features of the earth's climate, oceans, coasts and freshwater ecosystems that affect fisheries and aquaculture. Air and sea surface temperatures, rainfall, sea level, acidity of the ocean, wind patterns, and the intensity of tropical cyclones are all changing. The impact of climate change on aquatic ecosystems, and on fisheries and aquaculture, however, is not so well known.

Climate change is modifying the distribution and productivity of marine and freshwater species and is already affecting biological processes and altering food webs. The consequences for sustainability of aquatic ecosystems for fisheries and aquaculture, and for the people that depend on them, are uncertain. Some countries and fisheries will benefit while others will lose—the only certainty is change and decision-makers must be prepared for it.

It is clear that fishers, fish farmers and coastal inhabitants will bear the full force of these impacts through less stable livelihoods, changes in the availability and quality of fish for food, and rising risks to their health, safety and homes. Many fisheries-dependent communities already live a precarious and vulnerable existence because of poverty and their lack of social services and essential infrastructure. The well-being of these communities is further undermined by overexploited fishery resources and degraded ecosystems. The implications of climate change for food security and livelihoods in small island states and many developing countries are profound.

Investments are urgently needed to mitigate these growing threats, to adapt to their impacts and to build our knowledge of complex ocean and aquatic processes. The overarching requirement is to reduce global emissions of greenhouse gasses —the primary human driver of climate change. Fisheries and aquaculture need specific adaptation and mitigation measures that:

- improve the management of fisheries and aquaculture and the integrity and resilience of aquatic ecosystems
- respond to the opportunities for and threats to food and livelihood security due to climate change impacts, and
- help the fisheries and aquaculture sector reduce greenhouse gas emissions.

Healthy aquatic ecosystems contribute to food security and livelihoods

Fisheries and aquaculture contribute significantly to food security and livelihoods, but depend on healthy aquatic ecosystems. These contributions are often unrecognized and undervalued.

- Fish (including shellfish) provides essential nutrition for 3 billion people and at least 50% of animal protein and minerals to 400 million people in the poorest countries.
- Over 500 million people in developing countries depend, directly or indirectly, on fisheries and aquaculture for their livelihoods.
- Aquaculture is the world's fastest growing food production system, growing at 7% annually.
- Fish products are among the most widely traded foods, with more than 37% by volume of world production traded internationally.

Sustainable aquatic ecosystems are crucial for climate change adaptation

Healthy aquatic ecosystems are critical for production of wild fish and for some of the 'seed' and much of the feed for aquaculture. The productivity of coastal fisheries is closely tied to the health of coastal ecosystems, which provide food, habitats and nursery areas for fish. Estuaries, coral reefs, mangroves and sea grass beds are particularly important. In freshwater systems, ecosystem health and productivity is linked to water quality and flow and the health of wetlands. The stocks of small schooling fish like anchovies and sardines found in schools in the ocean are highly sensitive to changes in ocean conditions. These small pelagic fish are a basic food for millions and are often processed into fishmeal and used to feed cultured fish, as well as poultry and pigs.

Coastal ecosystems that support fisheries also help protect communities from the impacts of natural hazards and disasters. Mangroves create barriers to destructive waves from storms and hold sediments in place within their root systems, reducing coastal erosion. Healthy coral reefs, sea grass beds and wetlands provide similar benefits. Climate change imperils the structure and function of these already stressed ecosystems.

Crucial role of healthy oceans in climate change

- Oceans are the earth's main buffer to climate change and will likely bear the greatest burden of impacts.
- Oceans removed about 25% of atmospheric carbon dioxide emitted by human activities from 2000 to 2007.
- Oceans absorb more that 95% of the sun's radiation, making air temperatures tolerable for life on land.
- Oceans provide 85% of the water vapour in the atmosphere, and these clouds are key to regulating climate on land and sea.
- Ocean health influences the capacity of oceans to absorb carbon.

Fisheries and aquaculture can support mitigation and adaptation

Adaptation measures are well known by managers and decision makers, but political will and action is often lacking. To build resilience to the effects of climate change and derive sustainable benefits, fisheries and aquaculture managers need to adopt and adhere to best practices such as those described in the FAO Code of Conduct for Responsible Fisheries, reducing overfishing and rebuilding fish stocks. These practices need to be integrated more effectively with the management of river basins, watersheds and coastal zones.

Aquaculture of herbivorous species can provide nutritious food with a small carbon footprint. Farming of shellfish, such as oysters and mussels, is not only good business, but also helps clean coastal waters, while culturing aquatic plants helps remove wastes from polluted waters. In contrast to the potential declines in agricultural yields in many areas of the world, climate change opens new opportunities for aquaculture as increasing numbers of species are cultured, as the sea encroaches on coastal lands, as more dams and impoundments are constructed in river basins to buffer the effects of changing rainfall patterns, and as urban waste demands more innovative disposal.

Ecosystem approach – balancing resource use with nature's ability to respond to climate change

Coral reefs are degrading with increasing water temperatures and acidification of the oceans, and are growing more sensitive to the threats of over-fishing, pollution, poor tourism practices and invasive species. This will affect the quantity and type of fish available to coastal communities in developing countries and small island states. Ecosystem-based approaches to fisheries and coastal management are required. These approaches recognize the need for people to use coral reefs for their food security and livelihoods while enabling these valuable ecosystems to adapt to the effects of climate change, and to reduce the threats from other environmental stressess.

Fisheries and aquaculture need to be blended into national climate change adaptation strategies. Without careful planning, aquatic ecosystems, fisheries and aquaculture can potentially suffer as a result of adaptation measures applied by other sectors, such as increased use of dams and hydropower in catchments with high rainfall, or the construction of artificial coastal defences or marine wind farms.

Mitigation solutions reducing the carbon footprint of fisheries and aquaculture will require innovative approaches. One example is the recent inclusion of mangrove conservation as eligible for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) funding, which demonstrates the potential for catchment forest protection. Other approaches to explore include: linking vessel decommissioning with emissions reduction funding schemes, finding innovative but environmentally safe ways to sequester carbon in aquatic ecosystems, and developing low-carbon aquaculture production systems.

Many capture fisheries and their supporting ecosystems have been poorly managed, and the economic losses due to overfishing, pollution and habitat loss are estimated to exceed $50 billion per year. Improved governance, innovative technologies and more responsible practices can generate increased and sustainable benefits from fisheries. The current fishing fleet is too large to catch available fish resources efficiently and therefore consumes more fossil fuel than necessary. Reducing fleet overcapacity will not only help rebuild fish stocks and sustain global catches, but can substantially reduce carbon emissions from the sector.

Changing the investment climate

Increasing investment in fisheries, aquaculture and aquatic ecosystems is an investment in the 'liquid assets' of adaptation. Aquatic ecosystems play a crucial role in buffering and distributing climatic shocks, whether from storms, floods, coastal erosion or drought. Investment in aquatic science is fundamental—investment in knowledge of aquatic ecosystems, in the complex biological and chemical processes that determine the ocean carbon cycle, and in knowledge of the currents and eddies that generate hurricanes. Equally important is an understanding of the ways that people cope with and adapt to living in a changing climate, and how their institutions and livelihood systems have evolved to maintain resilience to future change in aquatic ecosystems.

Investment in awareness is also essential, from the local council considering a seawall to policy-makers considering fuel subsidies. Awareness is crucial for the millions who will lose their farms to the sea and need options and alternatives for their own investments and those of their local communities.

Vulnerability and risk assessment can inform these decisions; technologies and education can offer alternatives. Applying best practices in natural resources stewardship and governance is a 'no regrets' pathway, generating current and future benefits, increasing resilience of aquatic ecosystems and economies, and often reducing emissions.

What Can We Do Now?

- Implement comprehensive and integrated ecosystem approaches to managing coasts, oceans, fisheries, aquaculture; to adapting to climate change; and to reducing risk from natural disasters.
- Move to environmentally friendly and fuel-efficient fishing and aquaculture practices.
- Eliminate subsidies that promote overfishing and excess fishing capacity.
- Provide climate change education in schools and create greater awareness among all stakeholders.
- Undertake assessments of local vulnerability and risk to achieve climate proofing.
- Integrate aquaculture with other sectors.
- Build local ocean-climate models.
- Strengthen our knowledge of aquatic ecosystem dynamics and biogeochemical cycles such as ocean carbon and nitrogen cycles.
- Encourage sustainable, environmentally friendly biofuel production from algae and seaweed.
- Encourage funding mechanisms and innovations that benefit from synergies between adaptation and mitigation in fisheries and aquaculture.
- Conduct scientific and other studies (e.g. economic) to identify options for carbon sequestration by aquatic ecosystems which do not harm these and other ecosystems.
- Consider appropriate regulatory measures to safeguard the aquatic environment and its resources against adverse impacts of mitigation strategies and measures.

Implementing the aquatic agenda

Implementing adaptation and mitigation pathways for communities dependent on fisheries, aquaculture and aquatic ecosystems will need increased attention from policy-makers and planners. Sustainable and resilient aquatic ecosystems not only benefit fishers and coastal communities but also provide goods and services at national and global levels, for example, through improved food security and conservation of biodiversity.

For fishers, fish farmers and coastal peoples in the front line of climate change, for example, residents of low-lying developing countries and small island states, key actions should include securing resources to:

- Fill critical gaps in knowledge to assess the vulnerability of aquatic ecosystems, fisheries and aquaculture to climate change.
- Strengthen human and institutional capacity to identify the risks of climate change to coastal communities and fishing industries, and implement adaptation and mitigation measures.
- Raise awareness that healthy and productive ecosystems, which arise from well-managed fisheries and aquaculture, and careful use of catchments and coastal zones, are a crosssectoral responsibility.

Resources

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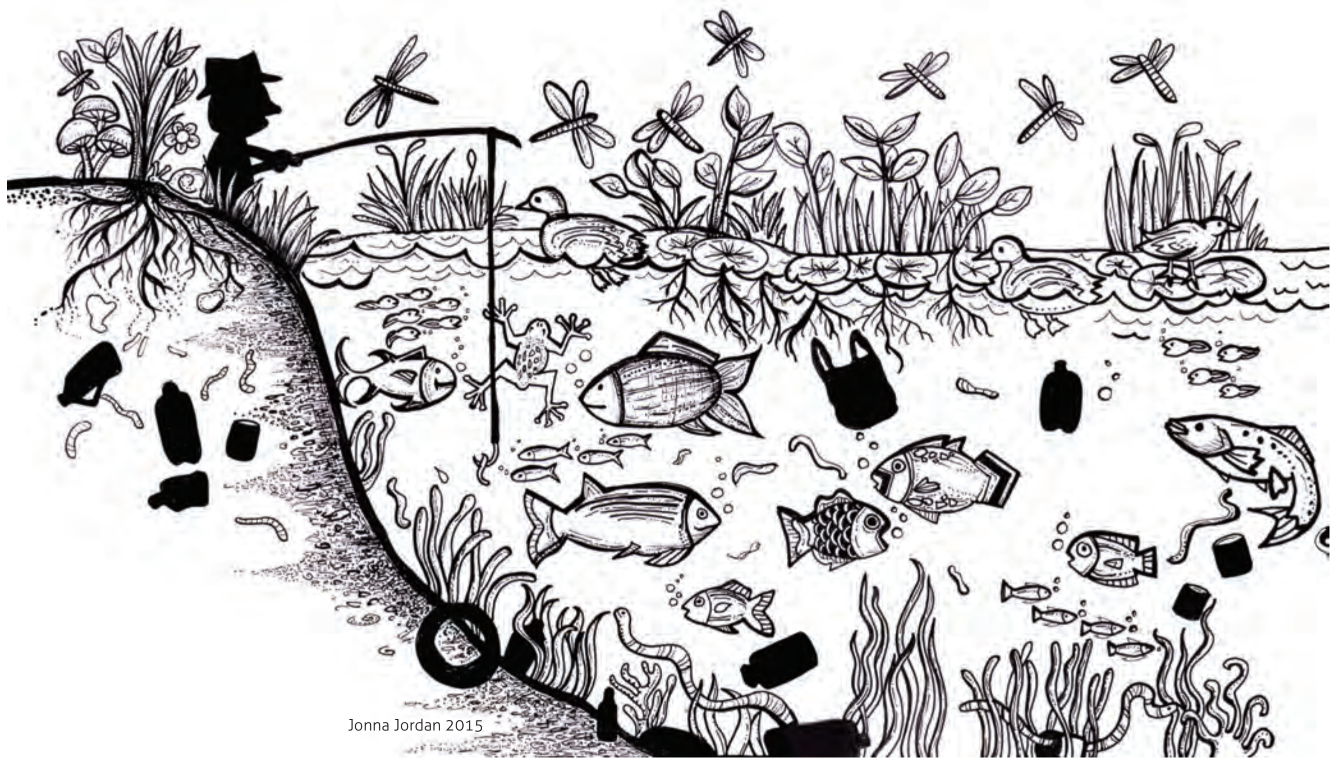
Source: Fisheries and Aquaculture in our Changing Climate

UNFCC COP – 15 in Copenhagen December 2009



Climate change, fisheries and aquaculture

Fisheries and aquaculture are threatened by climate change: higher water temperatures, rising sea levels, melting glaciers, changes in ocean salinity and acidity, more cyclones in some areas, less rain in others, shifting patterns and abundance of fish stocks. Climate change compromises the sustainability and productivity of a key economic and environmental resource, but it also presents opportunities, especially in aquaculture. Developing countries that depend on fish for food and exports will have a real challenge adjusting to the changes.

Impacts of climate change

Oceans, especially at mid-latitudes and the tropics, are warming and parts are becoming more saline. But in the subarctic Atlantic, the Southern Ocean and parts of the Pacific, oceans are becoming fresher. Increasing acidification threatens coral reefs, which are also endangered by rising temperatures that cause bleaching. Climate change affects the intensity and frequency of sea currents, which flush and clean continental shelf areas in 75 percent of the world's major fishing grounds.

This article was drawn from previously published materials entitled *Climate change, fisheries, and aquaculture* by Food and Agriculture Organization of the United Nations. Refer to the source box towards the end of this article for a complete reference to the original article.

Key facts:

- Fisheries employ more than 200 million people worldwide – 98 percent from developing countries.
- Small-scale fisheries support 99 percent of fishers but produce less than 50 percent of all fish.
- Aquatic products provide at least 50 percent of animal protein and minerals to 400 million people from the poorest African and South Asian countries.
- Countries most vulnerable to fisheries- and aquaculture-related climate change include those in West and Central Africa, northwest South America, and Southeast Asia.

Eighty percent of the world's freshwater fisheries are in Africa and Asia. Parts of both continents will experience greater warming than the global annual average, resulting in less rainfall and lower lake levels. Already lake levels are dropping, mainly because people are using more water.

The oceans in the tropics and mid-latitudes will be less productive but, by contrast, cold water oceans will see greater productivity. Many fish cannot tolerate swift rises in temperature. Fish distribution patterns will change, with the strongest and most rapid change to fish stocks at the edges of their species' range.

Species, particularly those with shorter life spans, will change the timing of their life cycle. Some plankton species will bloom earlier, resulting in mismatches between the early life stages of fish and their prey, and therefore declines in abundance.

Coral reefs are habitat for many of the world's marine species. Climate change threatens them in two ways: it causes coral reef bleaching and destruction while increased ocean acidity interrupts calcification. Corals cannot easily move into higher latitudes because there are no suitable surfaces where they can develop.

Risks to diet and food security

Fisheries and aquaculture play a crucial role for food supply, food security and income generation. Some 42 million people work directly as fishers and fish farmers, with hundreds of millions more engaged in associated activities—the great majority in developing countries. Fish exports boost foreign currency earnings—particularly important in developing economies. In fact, aquatic foods are the most widely traded foodstuffs, outpacing agricultural products.

Fish is a major source of protein in many poor people's diets, which are often dominated by starchy staples. Fish comprises about 20 percent of animal protein in the diets of over 2.8 billion people — and can reach 50 percent in the world's poorest regions, notably Africa and South Asia, and up to 90 percent in small island developing states and coastal areas.

Impacts of climate change will affect fisheries- and aquaculture-dependent people as production and marketing costs increase, buying power and exports decrease and dangers from harsher weather conditions rise. Small fishing communities in some areas will face greater uncertainty as availability, access, stability and use of aquatic food and supplies diminish and as work opportunities dwindle.

Developing countries are at greatest risk. In sub-Saharan Africa, Angola, Congo, Mali, Mauritania, Niger, Senegal and Sierra Leone are the most vulnerable countries. Semi-arid and with significant coastal or inland fisheries, they export large quantities of fish. Earnings from fish exports can be equivalent to 50 percent of the cost of their food imports.

Most of the people who work in small-scale fisheries are from developing countries. If fish distribution changes due to global warming, fishers with their small boats will be unable easily to follow the fish to new fishing grounds. These coastal populations also are threatened by more frequent storms and sea level rise.

River-dependent Asian fisheries, such as in Bangladesh, Cambodia and Pakistan, are also vulnerable to climate change as the abundance and diversity of riverine species are particularly sensitive to climatic disturbances.

Aquaculture: new opportunities

Now accounting for 45 percent of global seafood consumption, aquaculture production will continue rising to meet future demand. Here, climate change offers new opportunities. Production in warmer regions will likely increase because of better growth rates, a long growing season and the availability of new fish farming areas where it was once too cold. Aquaculture development opportunities will increase in some areas. This is particularly significant in tropical and sub-tropical regions, such as in Africa and Latin America.

At the same time, extreme weather events such as floods and cyclones could damage fish farms. In cool and temperate regions mollusc and salmon farms will be adversely affected by warming as the fish will not be able to survive algal blooms and new pathogens caused by higher temperatures.

Adaptation and mitigation strategies

Adaptation strategies should be based on an "ecosystem approach", defined as a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences, and developing appropriate management responses. In support of such an approach, ongoing study of the climate change phenomenon and its impact on the fisheries ecosystem will be crucial.

Although a relatively small contributor of greenhouse gas emissions, there are certainly areas in which fisheries and aquaculture have a responsibility to limit such emissions as much as possible. Decreasing carbon dioxide emissions will also improve the aquatic ecosystems' ability to respond to external shocks. For example, eliminating inefficient global fleets and fishing practices would reduce fuel needs; increasing efficiency of aquatic farms would decrease water and energy use; and reducing post harvest losses as well as increasing waste recycling will shrink the sector's carbon footprint.

Providing the best possible conditions to assure food security—quantity, access, use and timing of supply—calls for responsible management and governance. The FAO Code of Conduct for Responsible Fisheries and relevant international plans of action can be used as a basis for action.

Source: Climate Change, Fisheries, and Aquaculture

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Strategies for adaptation to climate change:

Examples from around the world

Widespread adoption of adaptation and mitigation strategies that will reduce the vulnerability of farming, fishing and forest communities depends on investment and advances in the three themes described above. The following sections describe a selection of the wide range of available strategies.

Adapting now

We do not need to wait for the uncertain conditions of the future to evolve—the climate today is already having significant negative impacts on the lives and livelihoods of poor people around the world. Indeed, droughts and floods are far from new phenomena, and farmers have developed various ways of coping with them, and other weather extremes, over the centuries. But poverty limits options, and the risk that the climate presents to agriculture plays a significant part in keeping farmers, and their families, in poverty.

This was repackaged from a longer title entitled *Climate, agriculture and food security: A strategy for change* by Anne Moorhead for the Alliance of CGIAR Centers. Refer to the source box towards the end of this article for a complete reference to the original article.

Without the back-up of insurance, small-scale farmers can lose everything if there is a weather 'shock'. To survive, they will probably have to sell any assets they possess, such as animals or farming tools, and when it is over they will be in a much worse position than they were before. The impacts of an extreme weather event can therefore last much longer than the actual event.

But even if the weather is favourable, the threat of possible bad weather is enough to limit growth. Poor farmers often choose not to invest in new technologies and opt for less risky but also less profitable crops, even when climate conditions are good. In addition, the climate risk limits their access to credit, because lenders know there is a high chance of default on the loan. So even if they wanted to invest in inputs to improve their farming system, they would probably be unable to. Although a weather shock may happen only one year in five or six, the threat limits growth in all years.

This is the climate—poverty conundrum, and it has been one of the most intractable problems limiting development. It has also clearly limited the uptake of agricultural innovations. Climate change will only add to the problem, and if the conundrum is not addressed, significant development reversals look very likely.

The emerging discipline of climate risk management (CRM) may hold some answers. CRM advocates the systematic use of climate information in planning and decision making at all levels, use of climate-informed technologies that reduce vulnerability to weather variability and uncertainty, and climate-informed policy and market-based interventions that transfer risk from vulnerable populations. CRM not only offers protection against the impacts of bad weather, but also opportunities to capitalize on favourable weather. It is applicable across climate-sensitive sectors, including health and water resources as well as agriculture and food security, and across all levels, from national adaptation plans to household coping strategies.

Feeding climate information into climate-limited livelihood systems holds a great deal of promise to improve the resilience of these systems. A handful of projects have turned this promise into reality. In Mali, the national meteorological service has been providing climate information to farmers in the form of forecasts and related advice for over two decades, and the farmers have also learned to monitor the weather themselves to improve their decision making. Results are significantly higher yields and higher incomes compared with non-participating farmers.

A broad range of tools and options come under the CRM umbrella, some familiar, others new. Index-based insurance is one of the newer options that could help transfer the climate risk from vulnerable populations to financial markets. Several pilot projects have demonstrated its feasibility, and there is currently a lot of interest in this approach. There are however some significant challenges to its widespread deployment which need to be addressed. For example index insurance, and many other CRM tools, depend on quality climate data that are currently often lacking, or not easily accessible, in developing countries.

Climate forecasts are an important CRM tool, and as climate science advances and they become more skilful, they offer great potential to help farmers manage the climate risk. Seasonal forecasts in particular are potentially very useful, but they currently seldom reach poor farmers in a useable form, and within a comprehensive package of information and support. Planning for the season ahead could be vastly improved; and the uncertainty that all forecasts contain could be managed with a tool such as index-based insurance. In other words, farmers prepare for the higher likelihood scenario, and insure against the lesser likelihood scenario.

Mainstreaming CRM principles into livelihood strategies will help farmers cope with weather variability and uncertainty. And coping with such variability today inevitably paves the way for adapting to climate change tomorrow. CRM is a natural complement to the climate-responsive technologies that agricultural research has produced—indeed, in some cases it could provide the 'missing link' that has limited their adoption so far.

Incorporating CRM into agricultural systems is the drive behind the fourth theme of the CCAFS Challenge Program, 'Adaptation pathways based on managing current climate risks'. Research will address knowledge gaps, for example those related to targeting, package design, institutional challenges to implementation at scale, and the implications of advance information. The aim is to incorporate CRM into agricultural development strategies, and ensure that the necessary climate services and support are in place.

Climate risk management in action

An agrometeorology project in Mali

Mali's national meteorological service launched a project some 25 years ago to provide climate information to rural people, especially farmers. The project was the first in Africa to supply climate-related advice directly to farmers, and to help them measure climate variables themselves, so that they could incorporate climate information into their decision making. Over the years, the project has evolved into an extensive and effective collaboration between government agencies, research institutions, media, extension services and farmers. Today, more than 2000 farmers are participating. Climate information is collected from diverse sources, including the World Meteorological Organization, the African Centre of Meteorological Application for Development, the national meteorological service, extension workers and farmers themselves. It is then processed and provided at three levels — seasonal forecasts, forecasts for the next 3 days, and 10-day bulletins that include information on the state of crops, water resources and weather conditions, as well as crop health issues, pastoral issues and agricultural markets. Data collected by the national meteorological service, as well as farmer testimonies, indicate significantly higher yields and incomes up to 80% higher for participating farmers. Farmers feel they are exposed to lower levels of risk and are therefore more confident about purchasing and using inputs such as improved seeds, fertilizer and pesticides.

Index insurance

Index insurance is insurance that is linked to an index, such as rainfall, temperature or crop yields, rather than actual loss. This approach solves some of the problems that limit access to traditional crop insurance in rural parts of developing countries. One key advantage is that transaction costs are lower, making index insurance financially viable for private-sector insurers and affordable to small farmers. The most common application so far is the use of an index of rainfall totals to insure against drought-related crop loss. Payouts occur when rainfall totals over an agreed period are below an agreed threshold that can be expected to result in crop loss. Unlike with traditional crop insurance, the insurance company does not need to visit farmers' fields to assess losses and determine payouts; instead it uses data from rain gauges near the farmer's field. As well as reducing costs, this means that payouts can be made quickly — a feature that reduces or avoids distress sales of assets. There are now several examples of index insurance in use around the world, including in India where it has been scaled up and is now bought by hundreds of thousands of farmers through both private sector and public schemes. ILRI is currently trialling an index-based livestock insurance scheme in Kenya, to protect against drought-related mortality during the short rain/short dry season spanning October 2009 to February 2010.

Drought monitoring and early warning

South Asia Drought Monitor is an evolving drought monitoring tool developed by IWMI. It uses freely available satellite data to monitor ground vegetation as an indication of drought progression. Reporting in near real time, the system currently covers Afghanistan, Pakistan and western parts of India. With further improvements, including building in weather forecasts, this could provide an effective early warning system for droughts, allowing early action to reduce impacts.

New—and old—ways with water

Drip irrigation

IWMI is working with local partners on 'bucket and drip' irrigation systems. Water flows from a raised bucket into pipes with emitters scattered throughout the plot, which discharge the water into the soil near the plants by means of a slow-release mechanism. Requiring an investment of only about US$5, these systems enable growers to apply just enough water to ensure good harvests. While IWMI is concentrating on southern Africa in this work, researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are helping introduce drip irrigation in West Africa's Sahel region for the production of high-value vegetables and fruits.

Water harvesting

Farmers in West Asia and North Africa, inhabiting some of the driest regions on earth, have for hundreds of years practiced water harvesting. This involves diversion of scarce rainfall from large areas into small parcels containing crops and trees. International Center for Research in the Dry Areas (ICARDA) scientists are studying traditional systems for water harvesting, with the aim of helping refine and disseminate them more widely. In Syria, for example, mechanized construction of traditional micro-catchment ridges has permitted the expansion of water harvesting in degraded rangelands. Meanwhile, the WorldFish Center is working in sub-Saharan Africa to help develop governance systems to guide water harvesting at the watershed level.

Flexible water storage options

Water storage—from groundwater, through soil moisture, small tanks and ponds, to small and large reservoirs—is going to be increasingly important for rural communities dealing with water scarcity, shorter rainy seasons and increasingly erratic precipitation patterns. Small, multi-purpose reservoirs offer a particularly valuable adaptation option. The Small Reservoirs Project, a Challenge Program on Water and Food (CPWF) project led by IWMI, is developing tools to help planners and stakeholders, particularly farming families, develop economically and environmentally sustainable small multi-use reservoirs and institutions for their communities.

Using wastewater

Wastewater is already used for food production in many resource-poor environments. As other water sources become less reliable and demand for food increases, wastewater will soon be seen as an asset not a problem. Irrigation with untreated, partly treated or diluted wastewater has environmental and health risks, but farmers use it because it is a reliable source (often the only source) throughout the year, and it often reduces or eliminates the need for fertilizer, among other reasons. IWMI is carrying out research in Pakistan, Ghana, Vietnam and Mexico, under a CPWF project, to reduce or eliminate the health risks and help policy makers and planners balance the needs of small farmers with the health of people and the environment.

Water policy under global change

A CPWF project led by IFPRI, Food and Water Security under Global Change, is working to understand the impacts of global change on agriculture and water resources at the global, national and river basin levels, to assess the effects of global change on water and food security in vulnerable rural areas of Africa, particularly rural Ethiopia and South Africa, and to identify adaptation measures that reduce the impacts of global change on these communities. The results will provide policy makers and stakeholders with tools to better understand, analyse and inform policy decisions for adaptation to global change.

Improving watershed management

In many situations, improved management of water requires not only actions by individual farmers but collective efforts to improve stewardship of this shared resource. Such approaches, requiring the empowerment of local rural institutions, are not easy to replicate on a large scale, but research done by IWMI suggests that 'irrigation management transfer' can be done. Similarly, ICRISAT has successfully promoted an integrated approach to watershed management in India and other Asian countries and is now beginning to transfer the innovation to Eastern Africa. An assessment of the impact of this approach in one watershed in India indicated that from 1998 to 2003 the use of new technologies, combined with traditional methods, almost doubled the incomes of small farmers, raised groundwater levels by 5–6 metres, expanded green cover from 129 to 200 hectares and more than doubled agricultural productivity.

Crops for the future

Drought-tolerant maize for Africa

Drought already reduces global maize yields by as much as 15% annually, and this looks set to worsen with climate change. To counter this, scientists from CIMMYT and the International Institute of Tropical Agriculture (IITA) are working with national partners in sub-Saharan Africa to develop drought-tolerant maize varieties. So far, more than 50 such varieties have been developed, and are being grown on a total of about one million hectares. The success of this work is partly the result of a novel breeding method, in which hundreds of small farmers take part in testing the new varieties.

New Rice for Africa

Rice is also at risk in Africa as the climate changes. New Rice for Africa, or NERICA, may help. Resulting from the work of the Africa Rice Center and its national partners, NERICA varieties combine the high productivity of Asian rice with the ability of African rice to tolerate harsh growing conditions. Varieties for rainfed uplands are already being grown on 200,000 hectares across 30 African countries. Farmers are particularly interested in early maturing NERICA varieties, which permit more intensive cropping and tend to escape intermittent droughts occurring at critical stages in crop development.

Flood-tolerant rice

With rising sea levels, flooding of coastal farmlands presents a real risk for farmers. Today in Southeast Asia, harvest losses related to flooding have an estimated annual value of US$1 billion. Rice is the only cereal crop that can withstand any degree of submergence, but most varieties die if fully submerged for more than 3 days. IRRI researchers and collaborators recently identified a rice gene called Sub1A, which allows plants to survive completely submerged for up to 2 weeks. The 'waterproofing' trait has been transferred into a popular rice variety in Bangladesh, and the improved version is giving high yields while protecting harvests against flooding.

The Rice and Climate Change Consortium

Capitalizing on successful results in developing rice tolerant to submergence and soil salinity (another condition expected to worsen as a result of climate change), IRRI has established a research consortium that is addressing the impact of climate change on rice production in all its complexity. Working from the local to global scales, the consortium relies on crop improvement, with the aid of molecular techniques, while also examining the impact of climate change on ecosystem resilience, pest dynamics and other factors.

Building on inherent drought tolerance

Among the world's most naturally hardy food crops are barley, cassava, millet and sorghum, which are widely grown in dry climates. These and other naturally tolerant crops contain a wealth of useful genes for plant breeders. Researchers at ICARDA, for example, are developing varieties of barley that mature earlier, and thus escape drought. Meanwhile in Africa, mechanisms behind the drought tolerance of cassava are being investigated by IITA and the Generation Challenge Programme. Researchers at ICRISAT have isolated genes for the so-called 'stay-green' trait in millet and sorghum.

Drought-tolerant beans

Researchers at CIAT have succeeded in breeding drought-tolerant common beans after nearly a quarter century of research. The new beans yield 600–750 kilograms per hectare under severe drought, roughly double the maximum yield that Latin American farmers get from commercial varieties under the same conditions.

Technologies to improve soils

Conservation agriculture

Conservation agriculture is based on minimal soil disturbance (reduced or no tillage), combined with organic matter retention (returning crop residues to the soil) and diverse crop

rotations. As well as reducing erosion and improving soil structure and soil–water dynamics, this approach also saves on labour, time, fuel and machinery wear. The combination of reduced soil disturbance and increased retention of crop residues also results in increased carbon storage (sequestration). A good example of the effectiveness of conservation agriculture is the rapid spread of 'zero tillage' technology in South Asia's rice–wheat systems. Promoted by a regional consortium with assistance from CIMMYT and IRRI, the technology has been rapidly taken up so that close to half a million farmers in India, Pakistan and other countries of the region now apply this technology on more than 3.2 million hectares, with economic benefits so far estimated at US$147 million. The Quesungual slash and mulch system provides another example. Developed under a CPWF project led by CIAT, this alternative to non-sustainable slash and burn is proving a success with resource-poor farmers in Honduras, Nicaragua and Colombia. Meanwhile, ICARDA is helping to test, validate and promote conservation agriculture practices in Syria, Iraq and Central Asia.

Eco-farming

Combining market orientation with soil rehabilitation, ICRISAT has developed a dryland farming system called the 'Sahelian eco-farm', which can multiply farmers' net income by a factor of six. Drought-tolerant, nitrogen-fixing trees such as Acacia species are planted to rebuild the soil, and high-value fruit trees, vegetables and herbal crops are intersown in the field. The leaf litter as well as decaying roots add organic matter to the soil and also reduce wind erosion and increase water infiltration. Small amounts of fertilizer complement the organic matter, and crop yields are boosted substantially.

Micro-dosing

Applying normal doses of fertilizer is too expensive for most farmers in the Sahel. The use of organic matter, in the form of livestock manure and crop residues, is effective, but supplies of these materials are often limited. A more economical alternative, developed by ICRISAT, is to apply small quantities of inorganic fertilizers in the hole where seed is sown, a practice called 'micro-dosing'. Practiced by thousands of farmers in Burkina Faso, Mali, Niger and Zimbabwe, micro-dosing helps crops mature more rapidly, yield 50–100% more grain, and escape the worst effects of drought.

Managing pests and diseases of the future

Modelling late blight

CIP researchers and collaborators are working on improving a late blight simulation model that was developed at Cornell University in the 1980s. The model was used extensively in the USA, but was found deficient when applied to epidemics in Ecuador or Peru. Researchers are now modifying the model to make it accurate in diverse agro-ecological environments. The model will be used to estimate changes in disease severity under different climate scenarios, and to test disease management options prior to validating them in the field.

Modelling potato pests

CIP scientists have also developed models to predict changes in range and biology of several insect pests of potatoes as the temperature rises. With a 2–3°C rise, the highly damaging potato tuber moth, for example, is expected to extend its range about 400–800 km north in the northern hemisphere, and also 100 metres in altitude in tropical mountainous regions. Moth activity will also increase, and lifecycle time will shorten.

Simulating tsetse-transmitted trypanosomiasis in Kenya

An ILRI project aims to build and test a predictive model that defines the relationships between climate change, land use and cover change, social systems and ecological disturbance on the distribution of tsetse flies and African trypanosomiasis or sleeping sickness across Kenya. The information produced will directly affect on-going tsetse control programmes and make a substantial contribution to understanding broader patterns of human—environment impacts, disease emergence, transmission, prevention and control, and future risk.

Ascochyta blight

Ascochyta blight is the world's most important chickpea disease. Caused by the fungus Ascochyta rabiei, favourable conditions for its spread are wet weather and mild temperatures. Traditional landrace varieties are highly susceptible, but ICARDA breeders have developed a range of elite lines that are moderately to highly resistant. These form a major component of a low-cost IPDM package to control the disease, which also includes use of high-quality seed pretreated with fungicide, crop rotation (to avoid fields with infected debris), delayed sowing (to ensure that humidity is low when plants are most vulnerable), weed control, more widely spaced plants (therefore less humidity within the plant canopy), and chemical fungicides used judiciously. However, climate change may mean that breeders have to return to the laboratory. Current improved varieties are only resistant in the early growth stages, which coincide with wet and mild weather when blight might occur. In the dryland regions where chickpea is grown, rain has normally been highly unlikely later in the season, but this could now change, requiring responses in the IPDM package.

Modelling rice diseases virulence in East Africa

Not only the geographical distribution of diseases, but also virulence is expected to change under a changing environment. Scientists at the Africa Rice Center are studying the effect of climate change on the virulence of blast and bacterial leaf blight in Rwanda, Uganda and Tanzania.

Innovations for livestock systems

Local breeds and participatory breeding

Local breeds of livestock are often tolerant to temperature extremes and can remain productive even on degraded rangeland. They are therefore likely to cope better with climate change than exotic breeds. Breeding programmes are therefore focusing on improving specific traits (e.g. milk yield, growth rate) in local breeds. To facilitate this, ILRI, ICARDA and their partners have developed a new approach called community-based participatory breeding. First, the community identifies specific breeding objectives. The entire community flock is then used as a single breeding pool to improve the target traits. Participatory breeding projects have been implemented in Ethiopia, Mexico, Kyrgyzstan and Tajikistan.

Fodder banks

Developed by ILRI and partners, fodder banks offer a feed management option particularly useful through scarce periods due to drought, for example. The 'bank' consists of a small area enclosed by a fence and planted with legumes such as Stylosanthes. A farmer uses this 'bank' as she would a larder or pantry, drawing on it when fresh food (green grass) is not available for her animals.

Replanting rangelands

As a result of overgrazing, cutting of shrubs and trees for fuel and removal of vegetation, valuable rangeland species are being replaced by less valuable species unpalatable to livestock. Researchers are looking for suitable replacement species that can provide fodder as well as help to rehabilitate degraded rangelands. ICARDA has successfully introduced several shrubs and drought-tolerant species, such as Atriplex and Acacia species and spineless cactus. Diversification of dairy products. Diversification of products can help increase the resilience of production systems. In some countries like Syria, the number of intensive dairy production systems has increased in recent years. Farmers process their own milk, mainly into yoghurt and local cheese, rather than selling it as fresh milk at a low price. Improving quality, shelf-life and marketability of these dairy products is critical for the farmers to respond to market standards on food safety and hygiene. ICARDA is working with these dairy farmers to help them improve both their processing and marketing skills.

Fisheries and aquaculture

Learning from communities

Through the CPWF, WorldFish is studying collective approaches to fish culture on seasonal floodplains in Bangladesh, Cambodia, China, Mali and Vietnam. The research seeks to understand how communities exposed to dramatic environmental variation adapt their livelihood strategies and design institutions that govern access to areas that are dry land in some seasons and under water in others. Developing locally appropriate fish-culture technologies and understanding the conditions for collective action to support them are first steps in developing adaptation strategies on these and other floodplains.

Learning from communities

WorldFish scientists have developed a participatory diagnostic and adaptive management framework for small-scale fisheries. This is being used to examine how fisherfolk are vulnerable to the compounding effects of multiple stresses in fishery systems, as well as exogenous economic, social and environmental drivers, and how they cope with them. The framework is currently being applied in two contexts: in tsunami-affected fishing communities in the Solomon Islands, where fisheries are already under a range of stresses, including overfishing, and face new threats such as climate impacts on coral reefs; and in the Niger River basin, which has a long history of vulnerability to drought and reduced river flow.

Diversifying livelihoods with aquaculture

WorldFish is working with Malawi's Fisheries Department to help farmers diversify into aquaculture. Farmers set aside a small amount of their land for fish farming. Fish are fed maize bran and household leftovers, while manure from goats, chicken and rabbits helps fertilize the ponds. In addition to using water from the ponds to irrigate maize fields (the traditional crop) and vegetables such as cabbage and tomatoes in their garden during the dry season, farmers grow cash crops like bananas and guava around the banks of their ponds. They use the water from the ponds directly or utilize the effect of seepage to provide moisture for their crops. Pond sediments make great fertilizers. Farmers produce some 1,500 kilograms of fish per hectare per year, providing high-quality protein for their families. The net farm income of adopters exceeds that of non-adopters by 60%, and their farms are also some 18% more productive than traditional ones during times of drought, increasing farm resilience and food security.

Salt-tolerant tilapia

Tilapia is one of the most widely farmed fish species in the world. Research has shown strain differences in tolerance to saline environments, and WorldFish scientists have begun to exploit this capacity to develop salt-tolerant strains.

Adaptation for forests

Forests of the Congo Basin. A large adaptation project led by CIFOR is undertaking research in the forests of the Congo Basin. It aims to develop adaptation strategies in the Congo Basin forests without jeopardizing the integrity of these forests to ensure the continuous provisioning of ecosystem goods and services vital for household livelihoods, national development and economic growth of the region.

Linking climate change adaptation and mitigation through agroforestry

Agroforestry systems are attractive land management practices that span both adaptation and mitigation objectives. Tree-based systems have some obvious advantages for maintaining production during wetter and drier years: trees are less susceptible than annual crops to weather variability and extremes like droughts or floods. Tree-based systems also deliver products such as fruits, fodder, fuel wood and timber. At the same time, they store significant amounts of carbon, in trees and soil. By adding trees to their systems, farmers are actively adapting to weather variability and uncertainty, and contributing to mitigation of future climate change.

Complex smallholder forest gardens

One of the most promising agricultural systems in the face of climate change is the complex forest garden. This approach, promoted by the World Agroforestry Centre, combines a wide range of crops, trees and animals in a flexible production system that offers economic as well as climate resilience. These systems make efficient and effective use of water and nutrients, and are adaptable as species viability changes with changes in the climate. Carbon storage in forest gardens is similar to levels in some natural forests, so they effectively address both mitigation and adaptation.

Building adaptive capacity

Building adaptive capacity in Zambia and Zimbabwe. ICRISAT is involved with a project that seeks to improve incentives and opportunities for households to cope with and adapt to the increasing vagaries of climate through improved crop production practices. The adoption of these practices will be stimulated by linking their dissemination with complementary investments in climate forecasting, and building linkages to other projects that have either a humanitarian relief focus or are involved in the development of input and product markets. Key interventions include: (1) building local institutions and demand-led rural service provision; (2) strategies and decision-support tools for managing smallholder assets, including livestock; and (3) participatory development of new technologies for natural resource use under variable rainfall.

Rehabilitating livelihoods following natural disasters

WorldFish has developed a framework for rehabilitating coastal livelihoods and communities following disasters. Building on lessons learned following the tsunami off Aceh in 2004 and an earthquake off the Solomon Islands in 2007, the rehabilitation framework stresses diversifying coastal livelihoods instead of just restoring practices of the past. It seeks to address the root causes of vulnerability and so build resilience in coastal communities that will enable them to cope with future threats and seize future opportunities.

A systems approach in the Andes

A CIP project called ALTAGRO is working in the high altitude regions of Peru and Bolivia, one of the poorest areas in the world and characterized by high weather variability and uncertainty. The project takes a systems approach that embraces both farming and non-farming activities. It represents a model for rural development based on a comprehensive view of sustainable agriculture, which encompasses the economic, biophysical, socio-cultural and environmental aspects of market-oriented development. Capacity building includes work with school children to introduce science-based concepts on climate change and variability to future farmers.

Mitigation opportunities

Reducing methane emissions from rice systems

Irrigated systems provide much of the world's food, but also produce greenhouse gases from chemical reactions between the water, fertilizers, soil bacteria and the plants themselves. Rice fields are often extensively flooded and produce significant amounts of methane. However, some simple changes in water regime can reduce emissions without yield losses. IRRI has demonstrated this in field experiments in the Philippines and beyond. Alternative wetting and drying replaced continuous flooding of rice fields, and farmers were able to see that yield was not reduced, and that water was used much more efficiently.

Reducing nitrous oxide emissions from soils

Nitrous oxide is produced by microbial action on nitrogen compounds which are usually added as fertilizer. Fertilizers are important for improving yields, but additions are generally highly inefficient, leading to emissions. The key is to increase nitrogen use efficiency by the plants, and there are various ways to do that. Fertilizer best management practices are based on the principle of 'right source, at the right rate, at the right time, and with the right placement'. A tool to help with this has been developed by CIMMYT researchers, which uses hand-held infrared sensors that measure how much nitrogen fertilizer farmers need to apply in their maize and wheat crops. Meanwhile, CIAT scientists are studying a chemical released from the roots of a forage grass which triggers a process called biological nitrification inhibition (BNI). This process slows the conversion of nitrogen compounds into nitrous oxide. If scientists succeed in isolating the genes responsible for BNI and can introduce it into other crops, the results could be truly revolutionary. Researchers at CIMMYT are seeking genes for BNI in wild plants related to wheat.

Reducing deforestation

Deforestation is a hugely complex issue, and reducing and reversing it requires action at many different levels, from global policy to local empowerment and diverse technologies that promote sustainable forest management. CIFOR is working across these levels to come up with solutions. Informing the policy debate, so that post-2012 agreements include REDD schemes that are equitable and provide benefits to communities, is a major area of focus. Providing information and tools that stakeholders need to bring about change is also high on CIFOR's agenda. For example, certification schemes that guarantee forest products are from sustainably managed forests are already helping small forest managers and communities identify and protect biodiversity across millions of hectares of tropical forests.
Lowering greenhouse gas emissions from livestock systems. There are many ways to reduce emissions from livestock systems, according to ILRI. Feeding better quality diets to ruminants reduces methane emissions, and can be facilitated with improved fodder technologies such as improved pasture species and use of legumes. Manipulation of rumen microflora and use of feed additives are also effective. Switching livestock species or breeds allows replacement of many low-producing animals with fewer but better fed animals, thus reducing total emissions while maintaining the supply of livestock products.

Managing soils for carbon sequestration

Soil carbon sequestration involves adding as much carbon as possible to the soil, and offers the biggest win—win mitigation—adaptation opportunity from farming systems. Conservation agriculture is one very effective approach; agroforestry is another. For example, the Quesungual slash and mulch system, developed by CIAT under the CPWF, is improving soils and livelihoods in South America. Annual crops and pastures are grown alongside replanted native forest vegetation. Management involves no burning and zero tillage. More than 6,000 farmers who have adopted the system during the last 10 years have more than doubled crop yields.

Mangrove conservation

Mangroves not only provide critical ecosystem services (including the provision of a nursery area for many juvenile fish, trapping sediments and preventing coastal erosion) but are also important sinks for carbon dioxide. Through a WorldFish project, Solomon Island researchers and government officers are being trained on the issues and opportunities associated with carbon credit trades, and the quantification of mangroves' contribution to carbon sequestration.

Methods for measuring greenhouse gases

Researchers at the World Agroforestry Centre have devised and are applying a new technique in Eastern Africa that assesses soil conditions, including carbon stocks, with a high degree of accuracy. Involving the use of satellite imagery and infrared spectroscopy, the technique is much cheaper than on-the-ground verification. Using this technology, a team of scientists in

Kenya is providing government officials with environmental data covering an area of 19,000 square kilometres to guide a comprehensive effort to rehabilitate degraded agricultural land in the watersheds that feed Lake Victoria.

Pro-poor biofuels

ICRISAT is assembling the elements of a biofuels initiative designed specifically to benefit the poor in regions facing the threat of desertification. One of the initiative's components consists of new varieties of high-sugar sorghum, which can be grown for ethanol production. Since sorghum produces grain and fodder as well, the new varieties should help address the food–feed–fuel dilemma. In addition, sweet sorghum is well adapted to drought-prone environments, requiring only a seventh of the amount of water required for sugarcane, another biofuel crop.

Source: Climate, agriculture and food security: A strategy for change

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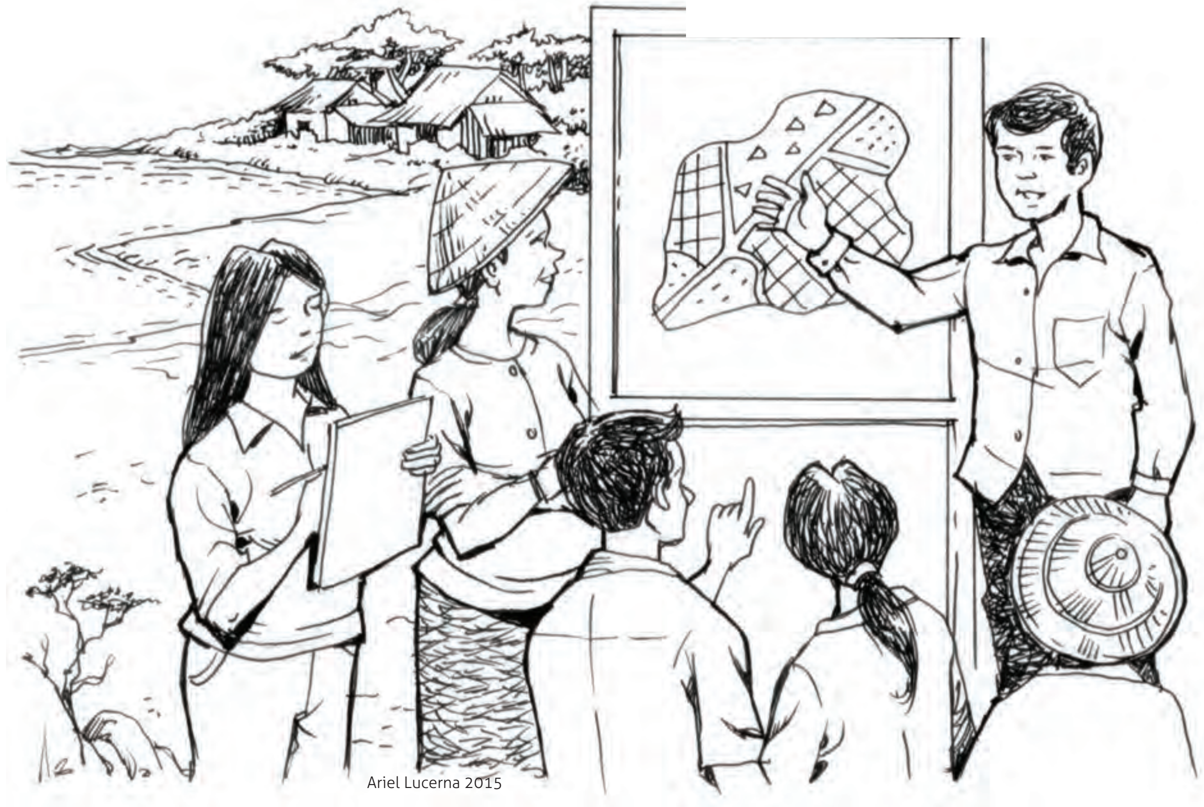


Ariel Lucerna 2015

Ecosystem-based approaches to adaptation

Role of ecosystems in adaptation

Ecosystems affect the climate and play an important role in adaptation to climate change. However, climate change affects ecosystems, their functions and the many benefits and services they provide to people along with the ability of ecosystems to regulate water flows and cycle nutrients. As these services are eroded, the implications of the impacts will be felt by people, communities and economies throughout the world. Climate change adds a further pressure on many ecosystems and people already negatively impacted by pollution, deforestation and land degradation. Loss of the services that ecosystems provide is also a significant barrier to the achievement of the Millennium Development Goals.

Adaptation strategies involve a range of actions, including behavioural change, technical or hard engineered solutions such as the construction of sea defences or risk management, and reduction strategies such as the establishment of early warning systems. There is also a growing recognition of the role that healthy ecosystems can play in increasing resilience and helping people to adapt to climate change through the delivery of the range of services that play a significant role in maintaining human well-being.

This article has been culled from a longer and comprehensive article entitled *Ecosystem-based approaches to adaptation: compilation of information.* Details of the original article is to be found in the source box towards the end of this article.

Approaches that involve the services that biodiversity and ecosystems provide as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change are known as ecosystem-based approaches to adaptation. The underlying principle is that healthy ecosystems can play a vital role in maintaining and increasing resilience to climate change and in reducing climate-related risk and vulnerability. Examples of such approaches include flood defence through the maintenance and/or restoration of wetlands and the conservation of agricultural biodiversity in order to support crop and livestock adaptation to climate change.

Implementation and benefits of ecosystem-based approaches to adaptation

Studies and reviews of ecosystem-based approaches to adaptation indicate that although the theoretical concept of ecosystem-based approaches to adaptation is fairly recent, practical approaches to adaptation that utilize the services of healthy ecosystems have been implemented in various guises by different communities for some time. These include approaches to deal with climatic variability developed by pastoralists and measures to reduce the effects of natural disasters.

The role of ecosystems in adaptation is relevant to, and can be applied at, many levels, such as the regional, national, subnational and local levels, and in all regions. Ecosystem-based approaches to adaptation are found to be most appropriately integrated into broader adaptation and development strategies, complementing, rather than being an alternative to, other approaches.

Ensuring healthy ecosystems is already an integral part of many adaptation strategies. Examples include integrating ecosystem-based approaches to adaptation into relevant strategies, including national adaptation programmes of action (NAPAs), flood control, disaster risk reduction planning and biodiversity strategies. Ecosystem-based approaches to adaptation also seem to be receiving increased attention in a policy context. Despite the fact that some initiatives did not start out as adaptation projects, there is evidence of the application of such approaches as a part of national and local adaptation portfolios.

Organizations, including many of the Nairobi work programme partner organizations from both the environment and development sectors, are engaged in research and implementation of ecosystem-based approaches to adaptation. Many Nairobi work programme partner organizations have made action pledges, outlining activities such as promoting the development of tools and methods for ecosystem-based adaptation, disseminating information and implementing pilot or demonstration projects. A number of collaborative initiatives are being taken forward to enhance knowledge and provide guidance to support the implementation of ecosystem-based approaches.

As part of an adaptation strategy, approaches that integrate healthy and intact ecosystems can deliver a number of benefits, including the following:

(a) Ecosystem-based approaches to adaptation are widely applicable at different spatial and temporal scales. This means that there is potential for considering ecosystem-based approaches in many circumstances;

(b) Ecosystem-based approaches to adaptation have the potential to reduce vulnerability to a broad range of climate and non-climate stresses. Such approaches have been shown to be effective for adaptation across sectors, contributing to livelihood sustenance and food security, sustainable water management, disaster risk reduction and biodiversity conservation;

(c) Ecosystem-based approaches to adaptation may be more cost-effective and accessible by rural or poor communities than measures based on hard infrastructure and engineering. Ecosystem-based approaches to adaptation can be particularly important to poor people, who are often the most directly dependent on the services that ecosystems provide;

(d) In addition to providing support for societal adaptation to climate change, ecosystem-based approaches to adaptation also provide for the possibility of multiple economic, social, environmental and cultural co-benefits. Approaches such as forest conservation or restoration of degraded wetlands can also contribute to climate change mitigation measures. Such win–win outcomes could also help to avoid maladaptation.

Lessons learned

The information reviewed for this compilation demonstrates that ecosystem-based adaptation is still a relatively new scientific field of endeavour, but that it is rooted in longstanding approaches applied by communities locally in response to episodic and/or long-term climate change. The science and knowledge base is emerging and demonstrates the benefits of such approaches, with case studies from both completed and ongoing projects providing useful evidence for the further evaluation and assessment of effective implementation. A wide range of organizations in multiple areas (conservation, development, disaster management) are engaged in implementation, including developing tools to aid the implementation of ecosystem-based approaches to adaptation.

As demonstrated by the range of case studies and knowledge products, projects on ecosystem-based approaches and/or with relevance to ecosystems address a broad range of climate change impacts, including drought, floods, storms, and ecosystem productivity and resilience.

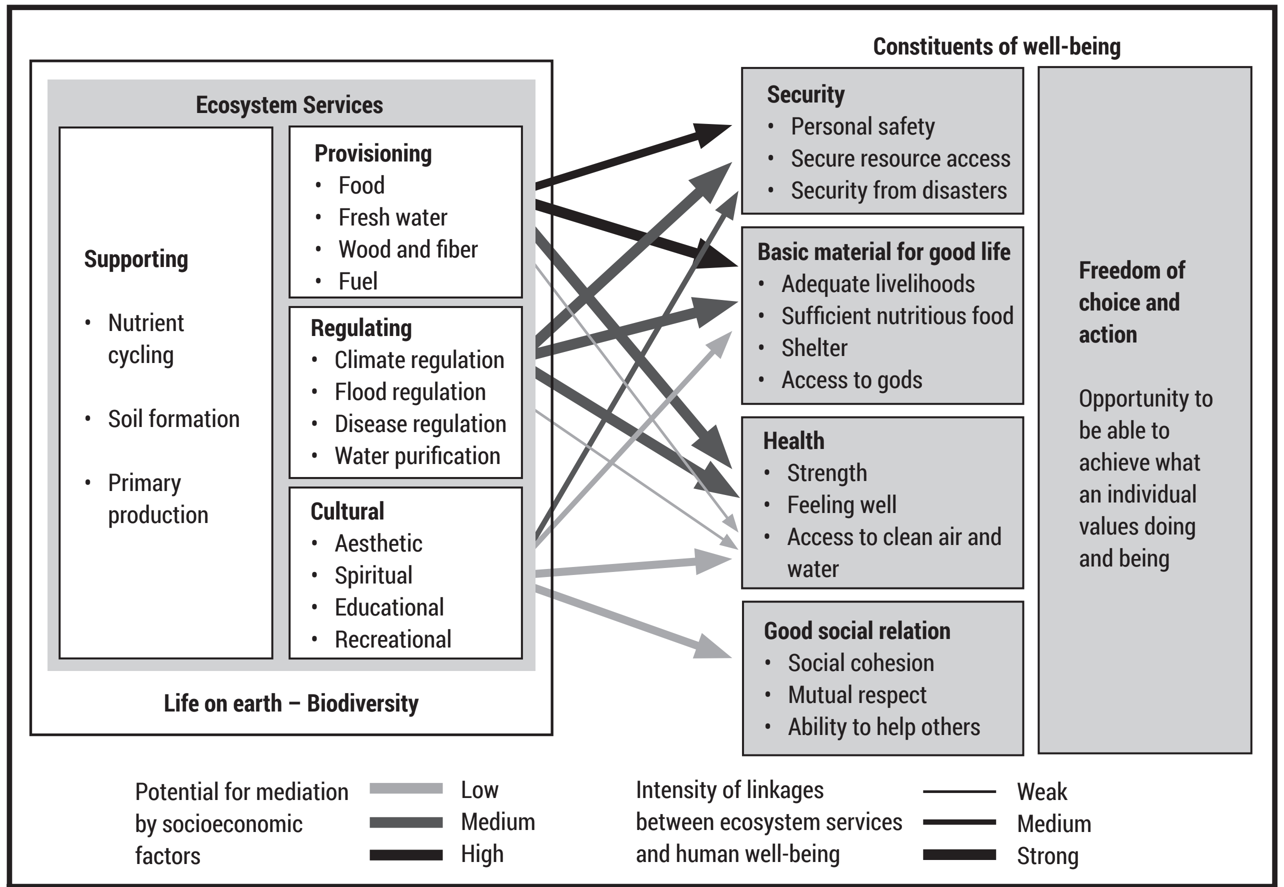
Lessons learned from the case studies illustrate the advantages of integrating ecosystem-based approaches within adaptation and development strategies in order to deliver a range of

The second CBD AHTEG on Biodiversity and Climate Change, convened in 2008– 2009 to provide scientific and technical advice and assessment on the integration of the conservation and sustainable use of biodiversity into climate change mitigation and adaptation activities, described ecosystem-based adaptation as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change." Such approaches to adaptation "use the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change" (Convention on Biological Diversity)." The principle is that such approaches aim to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change.

co-benefits that provide cost-effective opportunities to achieve multiple objectives relating to climate change, development and biodiversity. The case studies also demonstrate that ecosystem-based approaches are widely applicable to and particularly accessible by the most vulnerable communities. Other findings point to the importance of ensuring broad participation and learning from lessons learned from past interventions.

The case studies also identify a number of challenges to the implementation of ecosystem-based approaches to adaptation. These include circumstances that require a more engineered or technical response. Other challenges include ecosystem services being overlooked, misunderstood or ignored in adaptation planning.

While there is experience in the use of ecosystem-based approaches in the context of adaptation activities, improved and additional information about ecosystem interactions and practical guidance could help to enhance implementation.



Summary of ecosystem services, depicting the strength of linkages between categories of ecosystem services and components of human well-being that are commonly encountered

Source: Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington, D.C.: World Resources Institute.

Further developing the evidence base for ecosystem-based approaches to adaptation would help to enhance understanding of ecosystem interactions and the economics of ecosystem-based adaptation. Outcomes would need to be monitored and evaluated. The further development of networks to build capacity and share information and experience would also be helpful.

The following might be considered to enhance ecosystem-based approaches to adaptation at all levels:

(a) Targeted awareness-raising, both within the adaptation community (regarding the value of ecosystem-based approaches to adaptation) and within the areas responsible for ecosystem management (regarding the importance of adaptation);

(b) Capacity-building;

(c) Further research;

(d) Development of guidelines, tools, principles, etc.;

(e) Activities to enhance collaboration and coordination between relevant organizations, including among the Nairobi work programme partner organizations, for example:

  (i) Identifying the pool of expertise and organizations that are best suited to support ongoing activities related to ecosystem-based adaptation in the fields of science, policy and implementation;

  (ii) Identifying Parties' needs and ways in which countries can be supported when implementing activities;

(f) Increasing collaboration on activities related to ecosystems and adaptation between the three Rio Conventions, especially at the national level.

There is a growing recognition of the role that healthy ecosystems can play in increasing resilience and helping people adapt to climate change through the ongoing delivery of the range of services that help to maintain human well-being.

Examples of ecosystem-based approaches to adaptation include the following:

(a) Coastal defence through the maintenance and/or restoration of mangroves and other coastal wetlands to reduce coastal flooding and coastal erosion;

(b) Sustainable management of upland wetlands, forests and floodplains for the maintenance of water flow and water quality;

(c) Conservation and restoration of forests to stabilize land slopes and regulate water flows;

(d) Establishment of diverse agroforestry systems to cope with increased risk from changes in climatic conditions;

(e) Managing the spread of invasive alien species that are linked to land degradation and that threaten food security and water supplies;

(f) Managing ecosystems to complement protect and extend the longevity of investments in hard infrastructure;

(g) Conservation of agrobiodiversity to provide specific gene pools for crop and livestock adaptation to climate change;

(h) Establishing and effectively managing systems to ensure the continued delivery of the services ecosystems provide that increase resilience to climate change, for example through protected areas.

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Source: Ecosystem-based approaches to adaptation: compilation of information

Note by the Secretariat
By: United Nations Framework Convention on Climate Change
November 16, 2011

chapter 4

Climate stress and diminishing natural resources

- Degradation of natural resources and measures for mitigation
- Saving soils at degradation frontlines: Sustainable land management in drylands
- Soil biota and biodiversity: The ‘root’ of sustainable development
- Join the 4% initiative – soils for food security and climate
- Ten truths about conservation agriculture and smallholder farmers
- Effects of conservation agriculture on soils and natural resources
- Conservation practices to mitigate and adapt to climate change

Climate stress and diminishing natural resources

Desertification—land degradation in drylands—results from various factors including climatic variations and human activities. Once desertification takes its toll, water crises can contribute to conflict and exacerbate long-term imbalances between available water resources and demands. Desertification results in lost organic material, wind and water erosion, soil crusting, salinization, and other processes gradually rendering soils infertile. This further worsen the impact of climate change. This chapter outlines the key challenges posed by degradation of natural resources and examines techniques to prevent them. It highlights evidence in favor of adopting water harvesting or conservation agriculture techniques—where farmers who adopt integrated conservation practices can realize a higher return on investment.

Jonna Jordan 2015

Degradation of natural resources and measures for mitigation

Introduction

The degradation of natural resources is discussed in view of global trends concerning the achievement of the millennium development goals. At present, more than 800 million people suffer from chronic malnutrition—a number which hasn't changed over the past years (FAO 2006). Degradation is in this context understood as the reduction of the productive potential of a resource, i.e., either a decrease in qualitative terms or a quantitative decrease in the availability of the resource.

Nearly all of the soils under agricultural use show signs of degradation. This is obviously more severe in the tropics and has more dramatic impact than in moderate climate zones. However, the processes and consequences are in principle the same. Most visible signs for these degradation processes are increasing wind and water erosion and, as a result, disturbed water balances. Erosion, falling ground water tables, drying rivers or floods are only symptoms

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This article was drawn (after editing sections to shorten them) from previously published materials entitled *Degradation of natural resources and measures for mitigation* by Theodor Friedrich. Refer to the source box towards the end of this article for a complete reference to the original article.

caused in many cases by soil degradation. Particularly important in this respect is the decrease in soil organic matter, and as a consequence, a decrease in soil life and the loss of soil structure. Intensification of agriculture has led, particularly with progressing mechanization, to an intensification of soil tillage. In combination with a decreasing input of organic matter, this has resulted in a reduction in soil organic matter.

Degradation of natural resources

Nearly all agricultural soils of the world show signs of degradation. Most visible indicators are increasing wind and water erosion and as a result disturbed water balances. Erosion, falling ground water tables, drying rivers or floods, however, are only symptoms of soil degradation. Particularly important in this respect is the decrease in soil organic matter and subsequently a decrease in soil life and the loss of soil structure. Intensification of agriculture has led, particularly with progressing mechanization, to an intensification of soil tillage. This in combination with a decreasing input of organic matter led to a reduction in soil organic matter in some cases of dramatic dimension.

For example, the organic matter content of black chernosem soils in the Siberian steppe declined to half the original value since the beginning of cultivation. Depending on climate and soil, the loss of organic carbon in cultivated soils is 53–493 g/m² (Rusalimova et al. 2006). Organic matter levels of below 2 per cent are common on cultivated agricultural soils. The result, besides a bad soil structure, is also reduced fertilizer efficiency (Pell et al. 2004). The mineralization of soil organic matter in the tropics is more dramatic than in temperate climates. In the intensively cultivated plains of northern India, soils have an organic matter content of less than 0.1 per cent (PDCSR 2005). Increasing fertilizer rates do not lead to any yield increase under these conditions (Aulakh 2005). The global assessment of soil degradation demonstrates signs of soil degradation on all agriculturally used soils worldwide. The degradation is more advanced in tropical regions and leads to more dramatic consequences than in temperate climates (FAO 2000). However, the processes and results are the same everywhere. Agriculture, based on intensive soil tillage, leads to a reduction of the productive potential of soils, which becomes visible as structural degradation and leads finally to desertification (Shaxon and Barber 2003). This biological and physical degradation goes along with a chemical degradation. Increased leaching of nutrients leads to a depletion of nutrients in degraded soils. This causes a negative feedback in the way that nutrient poor soils have a reduced capacity to build up soil organic matter, even if organic material is supplied. For a recovery of such degraded soils, a balanced supply of mineral nutrients and organic matter is required (Probert 2007).

Water

Water is one of the most important resources for agricultural production. Agriculture accounts actually for about 70 per cent of the total consumption of available blue water (FAO 2002). With the actual trends in water consumption the demand for blue water will exceed the available resources in 2025 (Ragab and Prudhomme 2002). An important reason for the expected water shortage is not only the increasing demand but the careless use and waste of this precious resource. Wide landscapes are sealed by construction. Open

soils are increasingly compacted and do not allow the precipitation water to infiltrate completely and replenish the groundwater reserves. Excess water instead is led away through drainage channels without making proper use of it. Agriculture is increasingly part of the problem since most agricultural soils are, as a result of intensive cultivation, compacted and degraded and left with only a limited infiltration capacity. Forest areas are converted into agricultural land. The result of these developments is an increase in flood disasters (DBU 2002).

Climate change with increasing temperatures and less reliable rainfall will further aggravate the water problems in agriculture in many regions of the world. Problems can be expected even with the total yearly precipitation remaining the same, if the trend for less but more intensive rainfall events continues and the infiltration capacity of the soils is exceeded for each event. This seems to be the case more often in recent years (Met Office 2005).

Land

Besides soil as qualitative resource, the available land area is also an important factor for agricultural production. Land is also a limited resource and in some areas the available land for agriculture is already overexploited. In addition, there is a constant loss of agricultural land for non agricultural use, such as urbanization and road construction. This loss is estimated in countries with developing economies, excluding China, at about 1.3 million ha per year (Alexandratos, 1995). To this loss has to be added the land lost due to severe degradation and salinization.

Biodiversity

Agricultural production goes along usually with a decline in biodiversity. Diverse plant societies are replaced by single crops. Traditional varieties are replaced by a reduced number of high yielding breeds as a result of intensification. The use of modern production inputs leads further to a decline in micro flora and fauna. This is not only a matter of imaginary values but has also repercussions in production. Natural balances are disturbed and beneficial organisms are not anymore available to control pest populations, which leads to an increase in the use of agrochemicals ending in a vicious circle. The availability of nutrients and hence the efficiency of fertilizer use is affected by a decline of soil micro flora and fauna, leading to an increased use of fertilizer (Sprent 2007). An increased and rich biodiversity therefore can be of economic value in agricultural production (Bullock et al. 2001).

Climate and climate change

Climate is not really a resource and hence cannot degrade. However, agriculture is more than most other production areas heavily depending on climate. Any change of established climate patterns will therefore have a direct impact on agriculture. Since agricultural production practices have adapted to existing climate regimes over extended time periods, any change will create problems. This can be compared to a degradation process. As the latest IPCC report has clearly stated, not only is the climate changing, but the causes of the changes are not of natural origin but manmade (IPCC 2007). Agriculture is part of the process since about 40 per cent of land surface are under cultivation and human use (FAO 2006). The above mentioned degradation processes and deforestation have released major amounts of carbon into the atmosphere. Climate change is on one side characterized by a change in average temperature. This can have positive or negative repercussions. On the other side, the precipitation is affected, with varying regional trends. There will be winners and losers of climate change, but any change will require adaptation by changing production practices and will hence result in investment costs. More serious, however, is the trend to higher climate variability and less reliable weather conditions. This kind of change affects agriculture dramatically. Rainfall events are less reliable and less frequent but often with higher intensity. Also the temperature variations are more extreme (Met Office 2005). Any agricultural production system will suffer from these less reliable weather conditions.

Resource conserving practices

With the introduction of zero tillage in the early 1970s in Brazil, a new concept of agriculture was developed, named "direct seeding into straw" (plantio direto na palha), which is now growing world wide under the name of conservation agriculture (CA), using exactly these synergy effects. The concept had already been described by visionary people dating back to the early 1940s (Faulkner 1945, Fukuoka 1975). But only in Brazil it was extensively introduced into the agricultural practice accompanied by scientific investigation (Derpsch 2001).

During the history of agriculture a large number of resource conserving practices has been developed and recorded. This has even led to the creation of the World Overview of Conservation Approaches and Technologies (WOCAT) as an institution. WOCAT has collected an impressive amount of conservation technologies, mostly focussing on soil and water conservation (WOCAT 2007). Many of these traditional techniques tried to resolve a specific problem by physical means. Erosion, for example, is considered a problem.. Traditional erosion control tries with the 30 per cent soil cover to protect the soil surface physically from the impact of wind or water erosion by reducing the speed of the erosive medium. Also terraces and contour lines attempt to reduce the speed of surface run-off water limiting the erosive effect. Terraces, on the other side, have the disadvantage of being cost and labour intensive in their creation and they are often obstacles for agricultural mechanization (WOCAT 2007). Unresolved is the further loss of water, which has to be removed as surface water from the terraces. This leads often to gully erosion downhill. To make use of this water, further investment in collection and storage structures is required (WOCAT 2007).

Zero tillage practice is also considered as resource conserving technology. It leads to a reduction in the use of fuel and time inputs in production and further to an effective erosion control (Baker et al. 2007). Even more important is the reduced mineralization of soil organic matter under zero tillage which facilitates the capturing and storage of carbon dioxide from the atmosphere in the soil (Reicoscky 2001). In the long term, this leads to improved soil structure and increased water infiltration capacity of soils (DBU 2002). In addition to this zero tillage leads to a reduction in unproductive evaporation of soil water resulting in water savings of 15-20 per cent compared with conventional soil tillage (PDCSR 2005). On the downside, zero tillage can, as isolated technology, lead to problems with weed control and soil compaction.

Another interesting technique for soil conservation is controlled traffic farming using permanent tram lines. For this system, all the machines on a farm need a standardized track width which allows using always the same tram lines. These areas will never be cultivated again. The soil between the tram lines results in a better structure and free of any compaction, while the heavily compacted tramlines provide better trafficability and traction (RWC-CIMMYT, 2003).

Another resource conserving technology, independent of zero tillage, is direct seeding, particularly where it replaces the transplanting of small plants as, for example, in rice. Many rice growing areas are changing from traditional puddling and transplanting to direct seeding technologies. This saves labour, time, fuel, and water (PDCSR 2005). But also direct seeding as isolated technology leads to new problems with weed management and surface crusting (RWC-CIMMYT 2003). The use of green manure cover crops and crop residues as surface mulch does not only protect the soil against erosion. In case of legume cover crops, they can also lead to significant nitrogen supply of up to 200 kg.ha-1 depending on the growth conditions. This can lead to a 50-75 per cent reduction in the nitrogen fertilizer needs (RWC-CIMMYT 2003). Mulching with crop residues also reduces the evaporation of soil water resulting in water savings of 30 per cent (Bot and Benites 2005). Mulch covers on the other side require special equipment for seeding, without which they can become a serious problem for crop establishment. Also, incorporation of heavy crop residues into the soil can tie up soil nitrogen which then is not available to the crop. In wet soils, incorporation of organic matter can lead to undesired anaerobic fermentation zones.

While many of the so far mentioned techniques are beneficial for both, soil and water resources, there are also a large number of techniques focusing particularly on water consumption, especially under irrigated farming conditions. Significant water saving can be achieved with technical irrigation practices, especially with drip irrigation. This technology has been simplified and there are low cost applications available which are within the economic reach of small farmers in developing countries (WOCAT 2007). However, the surface irrigation is still the most widespread irrigation technique worldwide, in many cases with very low efficiency (FAO 2002a). But also surface irrigation can be improved by special preparation of the fields resulting in significant water savings. The micro-levelling of the soil surface with laser technology can result in water saving of up to 50 per cent compared to traditional farmers' practice. In traditional rice growing water saving of up to 70 per cent was reported. In the meantime, laser levelling carried out by contractors in India even for small farmers are accessible and economically feasible (Jat et al. 2006). In conventional tillage based agriculture, the laser levelling has to be repeated every 3-5 years.

A further water saving technology which is actually promoted in the Indo Gangetic plains of Pakistan, India and Bangladesh is the bedplanting with irrigation furrows between raised beds instead of basin irrigation, flooding the entire field. This practice has been successfully introduced in rice and wheat crops. Water saving of 26 per cent in wheat and 46 per cent in rice has been reported with yield increases of about 6 per cent (RWC-CIMMYT 2003).

Synergy effects of different techniques

The so far mentioned examples of resource conserving technologies all have advantages and disadvantages and are as isolated technologies not universally applicable. However, combining these technologies can create synergy effects which eliminate the disadvantages while retaining or even enhancing the advantages.

Global extent of conservation agriculture

It was estimated that the global extent of CA cropland in 2008/09 covered about 106 M ha (7.5% of global cropland) (Kassam et al., 2009). In 2013 it was about 157 M ha (11% of global cropland), representing a difference of some 51 M ha (some 47%) over the five year period (Table 1). CA in recent years has become a fast growing production system. While in 1973/74 CA was applied on only 2.8 M ha worldwide (Figure 1), the area had grown to 6.2 M ha in 1983/84 and to 38 M ha in 1996/97 (Derpsch, 1998). In 1999, worldwide adoption was 45 M ha, and by 2003 the area had grown to 72 M ha. In the last 10 years CA cropland area has expanded at an average rate of around 8.3 M ha per year, from 72 to 157 M ha. Since 2008/09, the rate of change has been about 10 M ha, showing the increased interest of farmers in the CA farming system approach, mainly in North and South America and in Australia, and more recently in Kazakhstan with large farms, and in India and China with small farms, where large increases in the adoption of CA are expected and indeed are occurring.

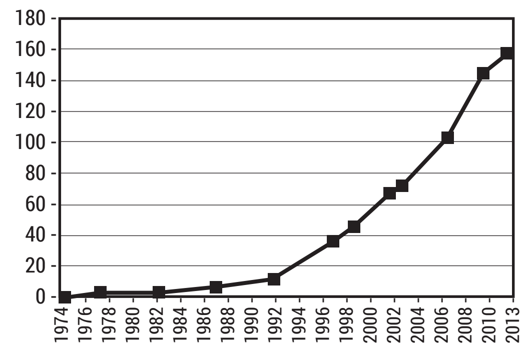

Figure 1. Global uptake of CA in M ha of arable cropland

Table 1. Extent of adoption of CA Worldwide by country in the 2008/09 and 2013 updates

Country	CA area 'ooo ha 2008/09 update	CA area 'ooo ha 2013 update
USA	26,500.00	35,613.00
Brazil	25,502.00	31,811.00
Argentina	19,719.00	29,181.00
Canada	13,481.00	18,313.00
Australia	12,000.00	17,695.00
China	1,330.00	6,670.00
Russia	-	4,500.00
Paraguay	2,400.00	3,000.00
Kazakhstan	1,300.00	2,000.00
India	-	1,500.00
Uruguay	655.10	1,072.00
Spain	650.00	792.00
Bolivia	706.00	706.00
Ukraine	100.00	700.00
Italy	80.00	380.00
South Africa	368.00	368.00
Zimbabwe	15.00	332.00
Venezuela	300.00	300.00
Finland	200.00	200.00
France	200.00	200.00
Zambia	40.00	200.00
Germany	354.00	200.00
Chile	180.00	180.00
New Zealand	162,00	162.00
Mozambique	9.00	152.00
United Kingdom	24.00	150.00
Colombia	102.00	127.00
Malawi	-	65.00
Turkey	-	45.00
Mexico	22.80	41.00
Moldova	-	40.00
Slovakia	10.00	35.00
Kenya	33.10	33.10
Portugal	25.00	32.00
Ghana	-	30.00
Syria	-	30.00
Tanzania	-	25.00
Greece	-	24.00
DPR Korea	-	23.00
Switzerland	9.00	17.00
Iraq	-	15.00
Sudan	10.00	10.00
Tunisia	6.00	8.00
Madagascar	-	6.00
Hungary	8.00	5.00
Morocco	4.00	4.00
Uzbekistan	-	2.45
Lesotho	0.13	2.00
Azerbaijan	-	1.30
Lebanon	-	1.20
Kyrgyzstan	-	0.70
Netherlands	-	0.50
Namibia	-	0.34
Belgium	-	0.27
Ireland	0.10	0.20
Total	106,505.23	156,980.96
% difference		47.39

source: FAO (2014b) - AQUATSTAT: www.fao/org.ag/ca/6c.html

Since 2008/09, the number of countries where CA has been adopted and being promoted has increased from 36 to at least 55 in 2013 as shown in Table 1. However, several countries where CA is known to be practiced are not included in Table 1. These include Vietnam, Cambodia and Laos in Asia, Ethiopia, Burkina Faso and Cameroon in Africa, and Denmark and Sweden in Europe. Further, the area of CA systems based on perennial crops or mixture of annual and perennial crops that is not included in the total CA area reported in this paper is on the increase in many countries in all continents. These CA systems involve plantation crops such as oil palm, cocoa, rubber, tea, coffee, coconut; orchards and vines such as olive, fruit and nut trees, grape, kiwi; pastures; and agroforestry. Thus the CA areas reported in this paper are conservative estimates.

The growth of the area under CA has been especially significant in South America where the MERCOSUR countries (Argentina, Brazil, Paraguay and Uruguay) are using the system on more than 70% of the total cultivated crop area. More than two thirds of no-tillage practiced in MERCOSUR is permanently under this system, in other words once started the soil is never tilled again.

As Table 2 shows some 66.4 M ha (42%) of the total global area under CA is in South America, corresponding to some 60% of the cropland in the region, and some 54 M ha (34%) is in the USA and Canada, corresponding to 24% of the cropland of the region. Some 17.9 M ha (11%)

Table 2. Cropland area under CA (M ha), CA area as % of total cropland, and CA area as % of cropland by continent, in 2013

Continent	Cropland under CA (MA ha)	Percent of global CA area	Percent of cropland
South America	66.4	42.3	60.0
North America	54.0	34.4	24.0
Australia & NZ	17.9	11.4	35.9
Asia	10.3	6.6	3.0
Russia & Ukraine	5.2	3.3	3.3
Europe	2.0	1.3	2.8
Africa	1.2	0.8	0.9
Global total	**157.0**	**100**	**10.9**

is in Australia and New Zealand, corresponding to 36% of the cropland and some 10.6 M ha (7%) is in Asia, corresponding to 3% of the cropland in the region. Some 8.4 M ha (5%) of the total global CA area is in the rest of the world, comprising 5.2 M ha in Russia and Ukraine, 2.0 M ha in Europe and 1.2 M ha in Africa, corresponding to about 3%, 3% and 1% of their total cropland respectively.

Final note

CA represents the core components of a new alternative paradigm and calls for a fundamental change in production system thinking. It is counterintuitive, novel and knowledge and management intensive. The roots of the origins of CA lie more in the farming communities than in the scientific community, and its spread has been largely farmer-driven supported by development-oriented agriculturalists. Experience and empirical evidence across many countries has shown that the rapid adoption and spread of CA requires a change in commitment and behaviour of all concerned stakeholders.

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Source: Degradation of Natural Resources and Measures for Mitigation

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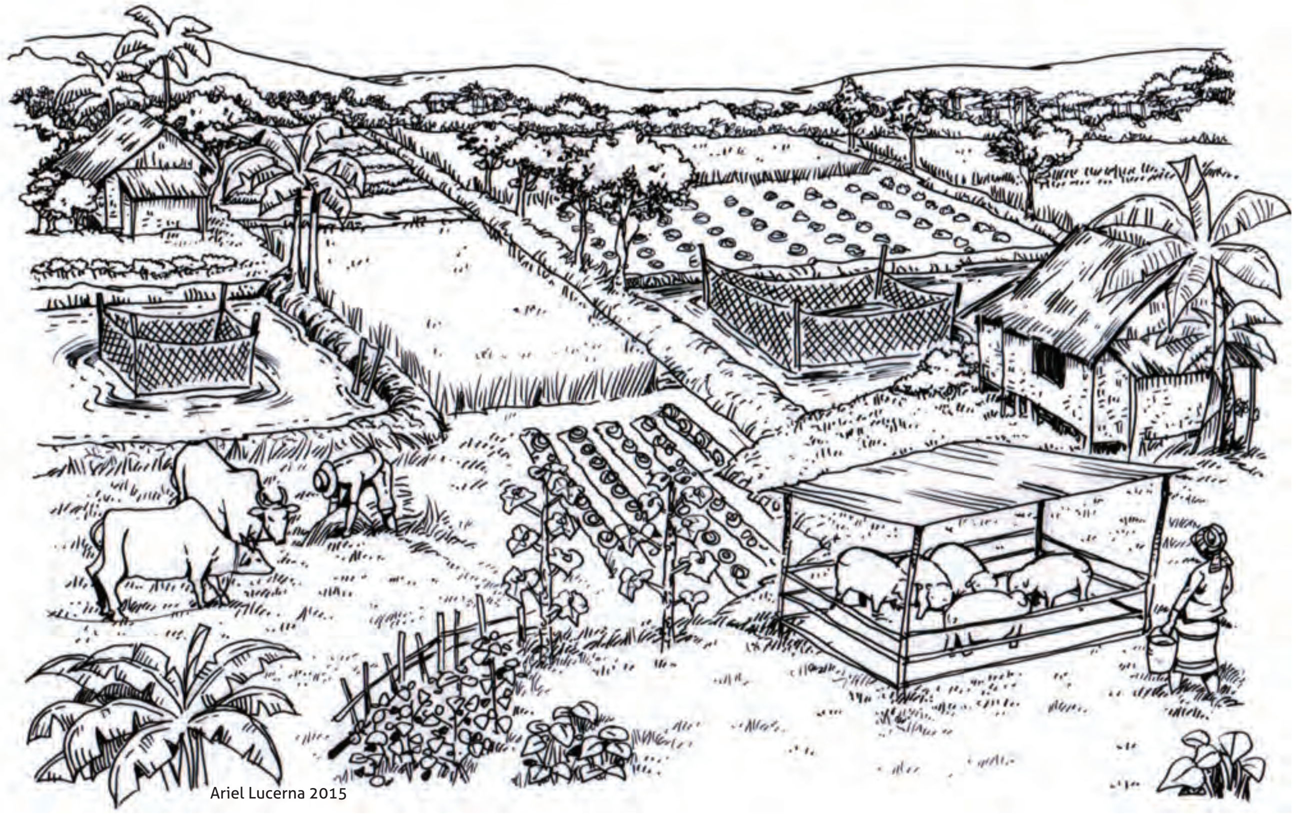

Saving soils at degradation frontlines:

Sustainable land management in drylands

Healthy soils are fundamental to life. They grow the food we eat and the wood we use for shelter and fuel, purify the water we drink, and hold fast to the roots of the natural world we cherish. They are the ground beneath our feet and beneath our homes. But they are under threat, especially from human overuse and climate change. Nowhere is this more evident than in dryland areas, where soil degradation—or desertification—wears away at this essential resource, sometimes with sudden rapidity when a tipping point is crossed. Though it is a challenge, preserving and restoring healthy soils in drylands is possible, and it concerns all of us. Sustainable land management points the way.

The threat of desertification

Desertification is insidious. It may not arrive with the fury of a hurricane or earthquake, but it is an environmental danger as big as any. Drought, loss of organic material, wind and water erosion,

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soil crusting, salinization, and other processes gradually render soils infertile. Twelve million hectares of fertile land are lost to desertification every year—three times the size of Switzerland. If we do nothing, desertification could ultimately jeopardize our ability to feed ourselves.

Desertification occurs in dryland areas, which cover 40% of the Earth's land surface. Despite their relative fragility, dryland ecosystems are home to two billion people. They include Mediterranean shrublands where olive and fruit trees grow, African grasslands with their pastoralists, the Great Plains of North America, and the Eurasian steppe where herders still tread the Silk Road. What unites them is the scarcity, infrequency, or unpredictability of rainfall.

Communities living in dryland areas are capable of stopping degradation and reviving healthy soils. Sustainable land management gives them the means. It turns the threat of desertification into opportunities: they can improve their productivity with minimal use of artificial inputs, increase biodiversity, create carbon sinks, maintain picturesque landscapes that attract visitors, and more.

Sustainable land management in drylands

CDE researchers have pioneered efforts to gather, document, assess, and share practices of sustainable land management through WOCAT (Box 1). Many of the land use practices have been refined over generations by everyday land users who are experts at efficiently harnessing nature's productive power, even under austere natural conditions. Growing drought- and fire-resistant fruit trees within rotational grazing systems is one example.

KEY MESSAGES

- We must tackle dryland desertification. It erodes productive soils and the livelihoods of 2 billion people. It destroys biodiversity, increases natural- disaster risks, contributes to population displacement, emits greenhouse gases, and threatens global food security.
- Sustainable land management offers a solution. It empowers rural communities in drylands, enabling them to halt or reverse desertification, increase production of food staples and livestock, improve incomes, preserve biodiversity and carbon sinks, maintain attractive landscapes for tourism, and more.
- Our tools help land users assess and select sustainable land management practices. This enables the informed, responsive, locally anchored stewardship that is needed to combat desertification.
- Funding and social support for land users practising sustainable land management should be maintained and expanded at every level. These land users protect and enhance public goods that benefit us all.

The researchers have recorded this vital knowledge, assessed its impacts on ecosystems and human well-being, and made it available for use by anyone anywhere.

Recently, CDE experts collaborated in a far-reaching five-year project, known as DESIRE, to study the impacts of sustainable land management technologies (and participatory ways of selecting technologies) in diverse dryland environments. The project studied 17 sites in 13 countries, from around the Mediterranean to as far away as China and Mexico. A follow-up project, called CASCADE, focuses on the potential of these practices to prevent sudden, irreversible degradation in Mediterranean drylands (Box 2).

Sustainable land management varies from place to place, but generally involves the following:

Joint assessment of local challenges, resources, and way forward

Each community faces a unique set of challenges. Our approach thus begins by bringing together key stakeholders—land users, local authorities, and others—to set their sustainable land management goals and decide how to achieve them. The goals might include reducing soil erosion and improving farm income. In two workshops, separated by a documentation phase using the WOCAT format, participants identify their problems (e.g. low productivity due to soil fertility loss), assess the potential solutions, and decide which technologies to implement. To maximize the likelihood of acceptance and to minimize the costs, priority goes to adapting and scaling up promising local practices. (Learn more at: http://www.desire-his.eu/en/potential-strategies)

Water, plants, structures, and stewardship

Sustainable land management practices focus on the following:

Water. They make every drop count. Instead of relying on irrigation water brought in from elsewhere, they capture, store, and channel what little rain does fall and make sure it is not immediately lost again through evaporation and surface runoff. Rainfall can be captured on roofs, in catchments, in recharge wells, etc. and directed into fields or into ponds for use later. There are many such rainwater harvesting technologies. In Spain and Tunisia, farmers harvest water upstream and divert it into their fields. One such scheme increased the amount of water available to crops from 300 mm to 500 mm a year. A recharge well in Tunisia captures floodwater from sporadic heavy rains and feeds it into an aquifer for storage.

Light-footprint irrigation technologies save water. Drip irrigation delivers small amounts of water to crops through hoses laid on, or just below, the surface.

Plants. Trees, crops, grasses, or a combination of these are vital to fight desertification. Roots hold soils together; litter on the surface allows water to infiltrate. Trees provide shade and shelter, and ground cover breaks the impact of raindrops. But what plants to grow? One possibility is nitrogen-fixing crops in rotation with other crops. Some legumes require little water and can be eaten (as in the Chilean project sites) or used for livestock fodder (in Turkey and Morocco). They can also be ploughed under to enhance soil fertility and structure, benefiting other crops (e.g. olives and almonds in Spain).

Box 1. World Overview of Conservation Approaches and Technologies (WOCAT)

Network: CDE researchers were founding members of WOCAT, a network of soil and water experts committed to documenting and sharing good practices of land use. Initially focused on conservation, they eventually developed the holistic concept of sustainable land management. This means using land resources—including soils, water, plants, and animals—to produce goods that meet changing human needs, while simultaneously ensuring the longterm productive potential of these resources and the maintenance of their environmental functions.

Online database: Today, WOCAT maintains an open online database of over 450 sustainable land management practices from 50 countries. Visitors may freely search, view, and download user-friendly materials covering the background, analysis, and "how to" of different practices. Sharing is encouraged! (https://www.wocat.net/en/knowledge-base/technologiesapproaches.html)

Questionnaires: The database is continually fed with new data collected in the field—from everyday land users and experts alike—using structured WOCAT questionnaires.

UNCCD endorsement: Since 2014, the United Nations Convention to Combat Desertification recommends use of the WOCAT database to its signatories (over 190 countries) in order to document best practices of land use around the world.

Elsewhere, it might be better to plant or preserve drought-resistant shrubs or trees. Large-scale afforestation can stabilize hillsides (documented in Cape Verde). Trees that protect the soil can also produce fuelwood (in Botswana) or fruits. Indeed, multipurpose use of landscapes is vital for sustainable land management.

Plant biodiversity is a natural extension of this. In Mexico, a community-led project included planting of agave (used to make drinks) in combination with grasses, shrubs, and trees—a panoply of plants serving many purposes.

Structures. Plants can form a living, durable barrier to heavy wind, rain, or floodwater. Planting dense rows of jatropha can prevent gullying on steep slopes in Ethiopia, for example.10 Strips of aloe vera, agave, olive trees, or saltbush (Atriplex) also make for effective plant barriers.

Sometimes it is necessary to move earth in order to control erosion. In the loess plateau in China, farmers built up terraces over a period of 5–10 years and reinforced them with apple

Box 2. Featured research: DESIRE and CASCADE projects

The findings and recommendations in this brief stem largely from the EU-funded DESIRE project (2007–2012). CDE experts were key collaborators in the project, in which researchers and local stakeholders jointly identified, documented, and assessed use of sustainable land management practices to fight desertification in drylands. In all, the application and impacts of 30 practices were documented in 17 dryland study sites (3,000 km2 of land in total). They were found to improve water management, reduce soil and vegetation degradation, improve land users' livelihoods, and have favourable long-term cost–benefit ratios (Schwilch et al. 2012).16 The follow-up CASCADE project (2012–2017) focuses on abrupt, often irreversible landscape degradation in drylands due to forest fires, overgrazing, or land abandonment. Researchers are studying how practices can minimize the risk of irreversible degradation and maximize the resilience of ecosystems. So far, 20 practices have been documented across six northern Mediterranean sites. (https://www.cde.unibe.ch/Pages/Project/4/69/The-CASCADE-Project.aspx)

trees. Fences woven from branches (in Turkey), stone checkdams, and rock walls trap soils, reinforce terraces, or buttress plant barriers.

Stewardship. Tying everything together is the stewardship of drylands. Crops must be harvested and rotated. Barriers and terraces need upkeep. Pests and plant diseases must be kept in check. Forests need thinning to cut fire risks. Soil fertility and moisture levels require monitoring. In Tunisia and Italy, livestock keepers graze their animals only in certain areas, allowing other areas to recover. That prevents overgrazing, protects or even enhances soil health, and produces valuable milk and meat. Because two-thirds of drylands are used for grazing, this holds immense potential.

Stewardship also includes no-till, a relatively new technique. This avoids ploughing; instead it uses special equipment to inject seeds directly into the soil. That preserves the soil cover and encourages water to infiltrate. It also keeps carbon in soils and out of the atmosphere, and costs less than conventional tilling due to labour and fuel savings. At sites used for cereal crops and orchards in Chile, Spain, and Greece, it reduced surface runoff and evaporation by over 50%.

Rural exodus: should I stay or should I go? Soil health is the result of a duet between people and nature. It requires locally anchored individuals and communities who tend the land, manage cycles, and respond flexibly to natural variations. So the exodus from many dryland areas is a pressing concern. It is easy to understand why people want to leave: job opportunities seem better elsewhere, and farming and herding may be low status work. Young people are especially drawn to cities. At the sites documented, over half the land users relied on off-farm employment for more than half of their income. They were more interested in using sustainable land management practices to increase their profits or to get subsidies than because they were worried about the environment or wanted to beautify the landscape.

More than anything, this highlights the need for national governments, regional bodies (e.g. the EU), and the private sector to provide adequate financial and social support (e.g. education) to dryland communities. Public awareness campaigns are needed to champion their work. By saving soils from desertification, they are doing nothing less than preserving life-support systems on behalf of everyone.

Current CDE research shows how land users often provide the last defence against catastrophic shifts in drylands, in which an environmental threshold is crossed (perhaps triggered by a fire or landslide) and a whole landscape rapidly degrades. It is much more cost-effective to invest in community-based prevention efforts than to restore landscapes already lost to degradation and desertification.

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Policy implications of research

Desertification threats demand a response
The risks of inaction on desertification are grave, while the opportunities of action are great. Inaction can lead to an accelerating cycle of lost productive land, biodiversity decline, natural disasters, population displacement, and rising carbon emissions.

The solution is to stabilize or increase production of staple grains and grass-fed livestock, protect resilient plant species, empower rural communities, and keep carbon in soils. A continuous effort is needed to properly care for dryland ecosystems, always seeking a balance between people's needs and nature's ability to replenish itself.

We may be the cause, but we are also the cure
Sustainable land management is needed to prevent, halt, or reverse desertification in many dryland areas. Fragile ecosystems have evolved over centuries or millennia. Leaving them alone to return to their "natural state" is largely illusory and risky. A deforested dryland landscape that has been farmed for generations is unlikely to revert to wild forest if it is abandoned – it is more likely to turn into (fire-prone) badlands. Informed, responsive, locally anchored stewardship is needed to help nature flourish in a mutually beneficial way.

Supporting sustainable land use is an act of solidarity that benefits us all
Not long ago, most people farmed for a living and were intimately aware of their reliance on healthy soils. While our awareness of the importance of soils may have changed, our ultimate dependence on them has not. Sustainable land management is a wise investment in the present and the future. Even in relatively well-off European countries – especially those with drylands (e.g. Spain, Portugal, Greece) – people are concerned about being able to produce enough food nationally and regionally.

Sustainable land management helps preserve that ability, and the many other ecosystem services of healthy soils. Rural communities that practise this form of land use maintain public goods that benefit everyone. They deserve to derive a fair living and a sense of pride from their work.

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Jonna Jordan 2015

Soil biota and biodiversity: The root of sustainable development

Soil organisms contribute a wide range of essential services to the sustainable functioning of all ecosystems by acting as the primary driving agents of nutrient cycling; regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission; modifying soil physical structure and water regime; enhancing the amount and efficiency of nutrient acquisition by vegetation; and enhancing plant health. These services are not only essential to the functioning of natural ecosystems but also constitute an important resource for the sustainable management of agricultural systems.

Soil is alive

Soils are one of the most poorly researched habitats on earth. Although not generally visible to the naked eye, soils are among the most diverse habitats and contain some of the most diverse assemblages of living organisms. The soil is one of nature's most complex ecosystems: it contains thousands of different organisms, which interact and contribute to the global cycles

This article was drawn from previously published materials entitled *Soil Biota and Biodiversity: The Root of Sustainable Development* by Food and Agriculture Organization of the United Nations. Refer to the source box towards the end of this article for a complete reference to the original article.

Key facts:

- Soil organisms maintain critical processes such as carbon storage, nutrient cycling and plant species diversity.
- Soil biodiversity plays a role in soil fertility, soil rehabilitation and nutrient uptake by plants, biodegradation processes, reducing hazardous waste and control of pests through natural biocontrol.
- Soil organisms enhance crop productivity through:
  - recycling the basic nutrients required for all ecosystems, including nitrogen, phosphorus, potassium and calcium;
  - breaking down organic matter into humus, hence enhancing soil moisture retention and reducing leaching of nutrients; and
  - increasing soil porosity and hence water infiltration and thereby reducing surface water runoff and decreasing erosion.
- Ecologically, the soil biota is responsible for regulating several critical functions in soil. Excessive reduction in soil biodiversity, especially the loss of keystone species and/or species with unique functions may have cascading ecological effects leading to the longterm deterioration of soil fertility and the loss of agricultural productive capacity.

that make all life possible—the life support systems. Nowhere in nature are species so densely packed as in soil communities. For example, a single gram of soil may contain many millions of individuals and several thousand species of bacteria. Soil biota also includes the roots that grow in the soil and interact with other species above and below ground.

The species numbers, composition and diversity of a given soil depend on many factors, including aeration, temperature, acidity, moisture, nutrient content and organic substrate. However, the number and types of organisms vary from one system and environment to another and this is strongly influenced by land management practices.

Agricultural practices, including forestry, have significant positive and negative impacts on soil biota. An integrated management approach to agriculture should, inter alia, enhance the biological efficiency of soil processes with a view to optimizing soil productivity and crop production and protection.

There are many cases in the literature demonstrating beneficial and negative effects of management practices on soil biological activity and its impacts on agricultural productivity and agro-ecosystem sustainability.

For example:

- Earthworms, termites and other burrow-building soil organisms enhance soil productivity by mixing the upper soil layers, which redistributes nutrients, aerates the soil and increases surface water infiltration.
- Worldwide, soil is being lost at a rate 13 to 80 times faster than it is being formed. It takes about 500 years to form 25 mm of soil under agricultural conditions, and about 1000 years to form the same amount in forest habitats. The value of soil biota to soil formation on agricultural land worldwide has been estimated at US$50,000 million per annum.
- Biological nitrogen fixation, the process by which some micro-organisms fix atmospheric nitrogen and make it available to the ecosystem, offers an economically attractive and ecologically sound means of reducing external nitrogen inputs and improving the quality and quantity of internal resources. Recent estimates indicate that global terrestrial biological N_2 fixation ranges between 100 and 290 million tonnes of N per year, of which 40-48 million tonnes per year is estimated to be biologically fixed in agricultural crops and fields.

Source: Soil Biota and Biodiversity: The "Root" of Sustainable Development
By: FAO

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Ariel Lucerna 2015

Join the 4% initiative– soils for food security and climate

Why 4%?

A '4%' annual growth rate of the soil carbon stock would make it possible to stop the present increase in atmospheric CO_2. This growth rate is not a normative target for every country but is intended to show that even a small increase in the soil carbon stock (agricultural soils, notably grasslands and pastures, and forest soils) is crucial to improve soil fertility and agricultural production and to contribute to achieving the long-term objective of limiting the temperature increase to +1.5/2°C, threshold beyond which the IPCC indicates that the effects of climate change are significant. This initiative is intended to complement the necessary efforts to comprehensively reduce global greenhouse gas emissions.

This article was drawn from previously published materials entitled *Join the 4% initiative soils for food security and climate.* Refer to the source box towards the end of this article for a complete reference to the original article.

Building on solid, scientific documentation and concrete actions on the ground, the "4% Initiative: soils for food security and climate" aims to show that food security and combating climate change are complementary and that agriculture provides solutions to climate change. This initiative consists of a voluntary action plan under the Lima Paris Agenda for Action (LPAA), backed up by a strong and ambitious research program.

One priority: agricultural soils to ensure food security

One simple fact:

- Soil degradation poses a threat to more than 40% of the Earth's land surfaces and climate change is accelerating this rate of soil degradation and threatening food security.
- Disastrous consequences for food security and family farmers.

Our capacity to feed 9.5 billion people in 2050 in a context of climate change will depend in particular on our ability to keep our soils alive. The health of soils, for which sufficient organic matter is the main indicator, strongly controls agricultural production. Stable and productive soils affect the resilience of farms to cope with the effects of climate change.

Primarily composed of carbon, the organic matter in soils plays a role in four important ecosystem services: resistance to soil erosion, soil water retention, soil fertility for plants and soil biodiversity. Even small changes of the soil carbon pool have tremendous effects both on agricultural productivity and on greenhouse gas balance.

Maintaining organic carbon-rich soils, restoring and improving degraded agricultural lands and, in general terms, increasing the soil carbon, play an important role in addressing the three-fold challenge of food security, adaptation of food systems and people to climate change, and the mitigation of anthropogenic emissions. To achieve this, concrete solutions do exist and need to be scaled up.

One vision: The 4% Initiative: soils for food security and climate

The 4% Initiative aims to improve the organic matter content and promote carbon sequestration in soils through the application of agricultural practices adapted to local situations economically, environmentally and socially, such as agro-ecology, agroforestry, conservation agriculture and landscape management.

- The Initiative engages stakeholders in a transition towards a productive, resilient agriculture, based on a sustainable soil management and generating jobs and incomes, hence ensuring sustainable development.
- Thanks to its high level of ambition, this Initiative is part of the Lima-Paris Action Agenda and contributes to the sustainable development goals to reach a land-degradation neutral world.
- All the stakeholders commit together in a voluntary action plan to implement farming practices that maintain or enhance soil carbon stock on as many agricultural soils as possible and to preserve carbon-rich soils. Every stakeholder commits on an objective, actions (including soil carbon stock management and other accompanying measures, for example index-based insurance, payment for ecosystem services, and so on), a time-line and resources.
- The Initiative aims to send out a strong signal concerning the potential of agriculture to contribute to the long-term objective of a carbon-neutral economy.

What is the added value of the 4% Initiative?

The 4% Initiative aims to develop practical measures on the ground that benefit crop and livestock farmers, the first victims of land degradation, and more broadly for the whole world population. This is a multi-partner initiative involving, in its first stage, all existing partnerships on soils and all stakeholders around two main strands of action:

- A multipartner (state and non-state actors) program of action for better management of soil carbon in order to combat poverty and food insecurity, while contributing to climate change adaptation and mitigation by:
  - the implementation of agricultural practices at local level and management of environments favourable to the restoration of soils, to an increase in their organic carbon stock and to the protection of carbon-rich soils and biodiversity;
  - the implementation of training and outreach programs to encourage such practices;
  - the financing of projects to restore, improve and/or preserve carbon stocks in soils;
  - the development and implementation of public policies and appropriate tools;
  - the development of supply chains of soil-friendly agricultural products, and so on.
- An international research and scientific cooperation program called *Soil carbon and food security* focused on four complementary research themes:
  - study of mechanisms and assessment of the potential for carbon storage in soils across regions and systems;
  - performance evaluation of best farming practices for soil carbon and their impact on other greenhouse gases, on food security and on other regulation and production services;
  - support of innovation and its promotion by appropriate policies;
  - monitoring and estimating variations in soil carbon stock, especially at farmers level. Joint action by all stakeholders should help attract new funding to the agricultural sector for adaptation to climate change, food security and emission mitigation, and encourage the implementation of adapted development policies and tools.

This initiative also aims to strengthen existing synergies between the three Rio Conventions the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD), the Committee for Food Security (CFS), the Global Soil Partnerphip (GSP), and the Sustainable Development Goals (SDGs), all which will be adopted by the United Nations in September 2015. Desertification, climate change and loss of biodiversity can either interact to pose a threat or, on the contrary, to help bring appropriate solutions to sustainable development. The principles of the 4% initiative will fully support the World Soil Charter (1988/2015).

The objective of this Initiative is to encourage stakeholders (state and non-state actors) to get involved in a coordinated effort.

Follow-up to the initiative: the initiative's partners will share the actions they commit to undertaking and the results achieved through a platform. Exchange of views and stocktaking meetings will be held regularly in order to organise the follow-up to this initiative.

How to contribute?

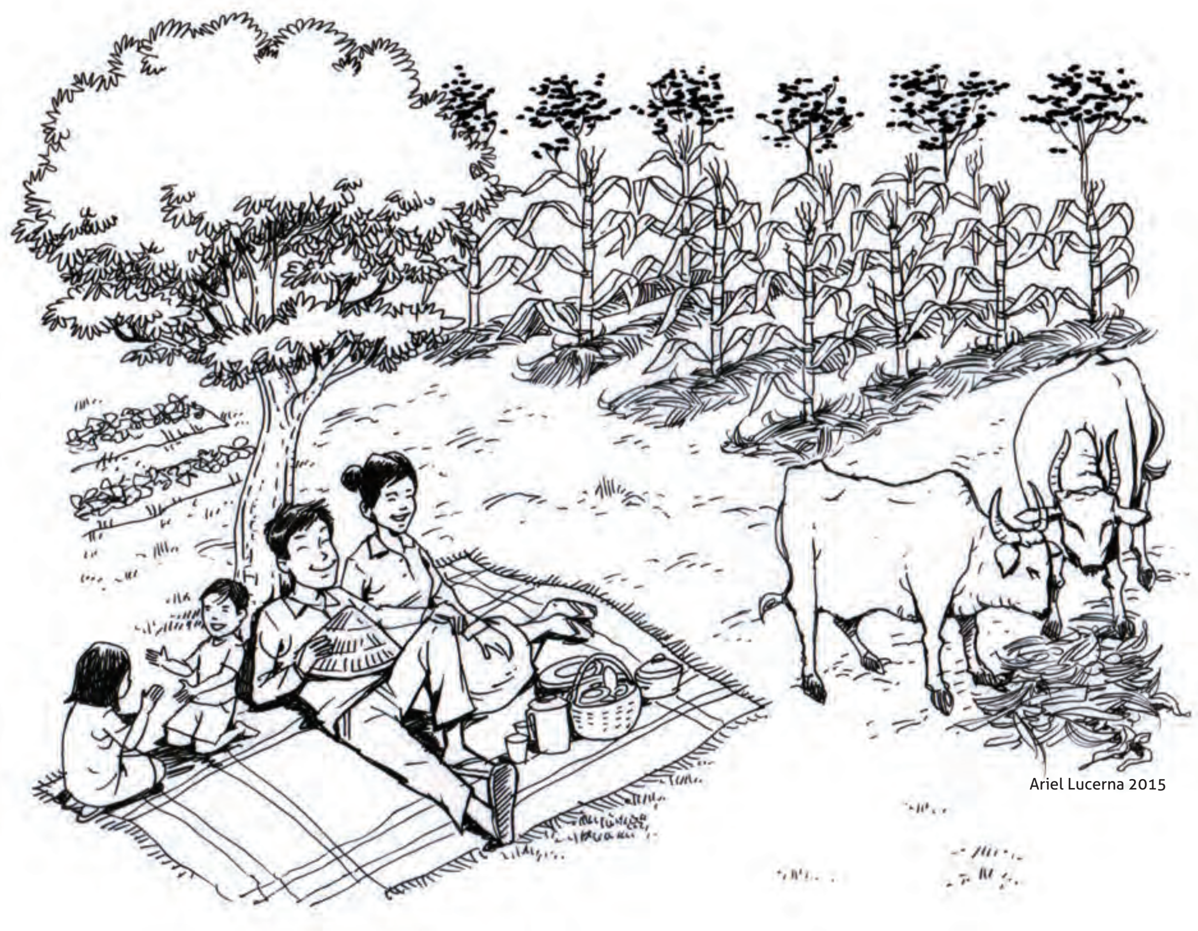
- Governments and local authorities can undertake to:
  - implement training programs for farmers and agricultural counsellors which aim to enhance organic matter in soils;
  - establish adapted public policies and tools in particular to land tenure and sustainable soil management;
  - support financially development project that helps to develop carbon sequestration;
  - develop policies to supply agricultural products promoting sustainable management of soils through public procurement, where appropriate.
- Development Banks, Donors and private foundations may:
  - adopt an ambitious goal for development projects facilitating the dissemination and implementation of agricultural practices to increase, stabilize the rate of organic matter in the soil and preserve carbon-rich soils;
  - finance development projects, research projects, trainings or the implementation of MRV systems.
- International research can develop the four above-mentioned strands of action.
- Private companies may undertake to:
  - encourage the supply of products resulting from practices which are beneficial for the soil carbon, as they do against deforestation;
  - engage in soil rehabilitation projects.
- Farmers' and Food Producers' organizations can contribute to and encourage the adoption of new practices to store a larger amount of carbon while increasing soil fertility and resilience, in collaboration with research and NGOs.
- NGOs will have a key role to play in identifying, adapting and facilitating the dissemination of these good practices and ensuring that they meet producers' expectations, in collaboration with research and farmers' organizations.

Key figures

- 24% of global soils are degraded at various levels, including 50% of agricultural soils [source: Bai et al. 2013]
- 1.500 billion tonnes of carbon are stocked in soil organic matter, which is twice more carbon than atmospheric CO^2 [source: IPCC 2013]
- 1.2 billion tonnes of carbon could be stocked every year in agricultural soils which represents an annual rate of 4% compared to the surface soil horizon [source: IPCC 2014]
- Every years crop production in Africa, Asia and South America could increase by millions, by increasing soil organic matter by 1 tonne/ha [Lal 2006]
- 1.2 billion USD is the economic loss in crop production due to soil degradation [FAO 2006]

Source: Join the 4% Initiative - Soils for food security and climate

For more information http://agriculture.gouv.fr/agriculture-et-foret/environnement-et-climat



Ten truths about conservation agriculture and smallholder farmers

There are growing numbers of smallholder farmers throughout the developing world who are successfully implementing conservation agriculture practices adapted to specific local conditions and existing crop and livestock production customs. As a result, farmers are using a wide variety of reduced tillage techniques and various means to protect soils with organic ground covers. It is clear conservation agriculture, like all agriculture practices, offers no single "silver-bullet solution" that satisfies every farm condition. The constraints and availability of natural resources, local climatic conditions, socio-economic policies and other factors all have a role in shaping a farmer's approach. However, conservation agriculture offers unique and critically-needed solutions to many of the challenges all farmers face, requiring us to make every effort to develop its full potential.

A rigorous scientific understanding of the success factors involved in conservation agriculture for smallholder farmers is only now being established. Consequently, much of the evidence

This article was drawn from previously published materials entitled *Ten truths about conservation agriculture and smallholder farmers* by Howard G. Buffett. Refer to the source box towards the end of this article for a complete reference to the original article.

that demonstrates conservation agriculture's potential for this group of farmers is drawn from a limited number of sub-scale development initiatives and underfunded research by scientific institutions and civil society organizations.

We do not have all of the answers but there is no question we need more public and private sector support for research in this area. There are many promising signs that investing in conservation agriculture practices will lead to improved farmer livelihoods, increase food security and enhanced local and global environmental quality. Examples of how it is being successfully implemented, and the scientific research that is providing solutions to key issues, are discussed in the following overview of conservation agriculture's basic truths and their applicability to smallholder farmers.

Truth # 1: Smallholder farmers who adopt integrated conservation agriculture practices can realize a higher return on investment in terms of labor savings, net income and improved soil quality.

- The Food and Agriculture Organization of the United Nations (FAO) studied nearly 5,000 smallholder farmers who adopted conservation agriculture practices in four different regions of Tanzania and Kenya following their participation in farmer field schools. Farmers who adopted conservation agriculture substantially reduced their labor inputs while also improving their crop yield from 26%-100% or more over a period of three to ten years. Farmers who used appropriate direct seeding equipment (e.g. a manual 'jabber') could plant a field of 0.4 hectares in three or four hours as compared to conventional tillage where three people working with hand hoes needed an entire day. (Shetto, at al. 2007)
- With conservation agriculture's reduced labor and time requirements for planting new crops, farmers are better able to sow seeds during the optimal planting 'window.' Studies indicate that for each day that seeding is delayed past the optimal planting period, harvested crop yields can be reduced by 1-1.5%. (Olaf Erenstein 2009)
- With the encouragement and support of the Ministry of Agriculture and several non-governmental organizations (NGOs), many smallholder farmers in Ghana have replaced their reliance on traditional 'slash and burn' cultivation methods with no-till and crop residue mulching practices that include the use of herbicides to control weeds. The International Maize and Wheat Improvement Center (CIMMYT) and the Crop Research Institute conducted field surveys of farmers in 30 different villages to determine the relative labor requirements of the two systems. These surveys found that the overall family labor inputs were 27% lower for those farmers who adopted conservation agriculture and their maize crop yields were 57% greater than those achieved by farmers who continued to rely on slash and burn practices. (J. Ekboir 2002)
- The World Food Programme's (WFP) Purchase for Progress (P4P) program has reported that participating Nicaraguan smallholder farmers' adoption of conservation agriculture practices has enabled them to reduce their production costs by 40%. (Ken Davies, WFP/P4P Coordinator. 2012)
- The carbon sequestration potential of conservation agriculture practices is variable. However, many studies have shown that soil organic carbon (SOC, aka carbon) levels under no-till are much higher in the first 10 centimeters of topsoil than in soils under conventional tillage (e.g. approximately 75% higher at a five cm depth and 40% higher at a 10 cm depth). SOC levels are similar at 20-30 cm depths for both systems. Models indicate that total SOC under conservation agriculture could be 10-30% greater than for conventional tillage. (Robert, et al. 2001)
- A meta analysis of 67 long-term agriculture experiments that compared soil carbon sequestration rates between no-till and conventional tillage practices found that the transition from tillage to no-till practices could continually sequester an average 480 kg C/ha/year over a period of 15-20 years until the SOC levels reach a stable equilibrium. (T. West and W. Post 2002).
- Ratan Lal, the Director of the carbon Management and Sequestration Center at Ohio State University has reported that the SOC levels of natural ecosystems have been significantly depleted by historical land misuse and poor management of soils. Lal notes that if farmers adopted "recommended management practices" that include conservation agriculture with no-till farming, residue mulching, cover cropping, crop rotations, appropriate use of both organic and inorganic fertilizers and other related land stewardship techniques, approximately 100 to 1000 kg C/ha/year could be sustainably sequestered until a new equilibrium level of SOC is achieved over a 25-50 year period. (Lal et al. 2003)

Truth # 2: A combination of education and site-specific analysis will help balance competing uses for crop residue.

- An International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) study of the dual use (soil conservation vs. livestock feed) of crop residues in Niger indicated that the nutrient content of some crop residues is unevenly distributed throughout the plant segments (e.g. stalks, stems, panicles, etc.). In such crop residues the lower structural biomass has very little nutritious value as livestock feed. It is believed that for some crops (e.g. millet), nearly 40% of total residues could be more valuable in contributing to overall farm productivity and farmer income if used as ground cover for soil conservation that increase crop yields rather than as fodder for livestock. (Powell and Fussell 1993)
- The Consultative Group on International Agricultural Research (CGIAR) Systemwide Livestock Programme's analysis of the economic trade-offs between using crop residues for ground cover mulches or for fodder in West Africa found that optimum returns were possible with varying levels of crop residue retention across different locations and crop varieties. In some cases the majority of residues should be used for soil cover and nutrient recycling; in other cases using a majority of residues for fodder provided farmers with the highest return. (IITA et al. 2011)
- In some communities, farmers protect their crop residue mulches from free grazing livestock by discussing the importance of organic ground cover for crop productivity with village governing organizations and their neighbors. In some areas community self-governance groups prohibit free grazing livestock practices, resulting in residues being retained for mulch. (CA-SARD project. CA Cases from Tanzania.)
- Farmers have cultivated livestock fodder crops on field contours and set aside areas and then harvested these crops as 'cut and carry' feed for corralled livestock. These practices have resulted in crop residues being available for use as mulch and enabled farmers to effectively collect manure for use as organic fertilizer. (Bolliger et al. 2006)

Truth # 3: Diverse varieties of cover crops, crop rotations and substantial residue retention can reduce reliance on herbicides.

- As farmers gain experience in growing cover crops that control weeds, weed pressures can be reduced. Ground cover residues and green manure crops can also suppress weed infestations in later years to a level that enables farmers to use a fraction of the herbicides that were originally needed. (Steiner, et al. 2012.)
- In lobg-term field trials in Malawi, CIMMYT researchers found that the use of cover crops and green manures over a period of seven cropping seasons could control weeds without the need for further applications of herbicides. (Bram Govaerts 2012.)
- Multi-year crop rotations with different plant varieties have significantly reduced the need for herbicides to control weeds. A study in Iowa of Low External Input (LEI) farming practices compared conventional two-year corn/soybean rotations with three- and four-year rotations of corn with N-fixing crops. The study found that over a four-year period the longer rotations significantly reduced the need for herbicides (i.e. by 76% and 82% respectively) and synthetic fertilizers (i.e. by 59% and 74% respectively). The rotational crops' allelopathic biochemical and ground cover competition properties may explain the superior weed control results. (M. Leibman, et al. 2008.)

Truth # 4: Efforts to identify crops adapted to local conditions, building capacity of farm organizations and improving smallholder access to key inputs are gaining traction.

- Since 2006, the Program for Africa's Seed Systems (PASS) has provided technical and financial support to local research institutions for the development of their institutional capacity and scientific breeding of high-yielding, disease resistant maize, cassava and rice varieties. PASS also links research institutions with local seed companies and provides direct loans and equity investments to emerging seed companies where necessary. These efforts ensure farmers are aware of improved seeds, can access them and get the extension services they need to improve yields. To date over 60 independent seed companies have been created (with another 40 planned by 2017) and over 9,000 agro-dealers have been trained and networked, resulting in 373,283 MT of seed sold to African farmers. In 2010, 21 MSc and 10 PhD students supported by PASS graduated, helping to build critical technical and research capacity. Our foundation has supported the expansion of PASS's efforts into Sierra Leone, Liberia and South Sudan. (AGRA Annual Report, 2010.)
- NGOs and agricultural research institutions are developing and propagating green manure cover crops and N-fixing plants and woody legumes that are adapted to African agroclimatic conditions. In addition, Farmer Field Schools are encouraging farmers to establish local seed banks in which a variety of rotational and cover crop seeds and seedlings are produced and exchanged within the community. (Eotuleo Farmer Field School: CA-SARD Project. CA Cases from Tanzania.)
- The World Food Programme's P4P is a 21-country pilot project to source commodities for WFP's food assistance efforts from local smallholder farmers. As part of the program in Central America, P4P provides conservation agriculture extension services to participating farmer organizations. One element of this training induced N-fixing bean varieties to women farmers in Guatemala. By adding these legumes to their intercropping and crop rotation practices, the farmers improved the nutrition of their diets, introduced an additional source of income from the sale of these beans and naturally produced N fertilizer for their fields. (WFP. P4P January Update 2011.)
- CARE International's Hillside Conservation Agriculture Project (HICAP) in Tanzania encouraged participating farmers to cultivate N-fixing cover crops (e.g. pigeon pea, lablab and cowpeas) that could be harvested for sale as starter seeds to other farmers. The HICAP project also facilitated seed distribution to farmers in the area to support FARMER Field Schools and demonstration plots. (CARE HICAP Project Annual Report to HGBF. 2012.)

Truth # 5: Many smallholders who adopt conservation agriculture experience increased crop yields.

- Long-term conservation agriculture field research in Mexico demonstrates that conservation agriculture practices for maize and wheat production consistently achieved higher yields over conventional practices from the first year onward. In the initial year of the study conservation agriculture maize and wheat yields were respectively 20% and 33% greater. Conservation agriculture yields for both crops were particularly better during drought years when conservation agriculture's enhanced soil moisture retention properties had a positive impact on grain production. (Erenstein, et al. 2008.)
- Immediate crop yield improvements were achieved by farmers participating in CARE International's farmer field school demonstration project in Tanzania. These farmers had an average yield grain of 87% over the conventional control plot yields in the first year. (CARE International HICAP Project report to HGBF, 2012.)

Truth # 6: Conservation agriculture's focus on soil health, reduced erosion and an emphasis on crop diversity reduced the exposure of smallholders to crop failures.

- Long term field research by CIMMYT indicates that zero tillage with retention of residues significantly improves soil moisture levels and enables crop yields that are far greater than those from conventional practices during extended dry periods. (Verhulst, et al. 2011.)
- The Tropical Soil Biology and Fertility Institute of the International Center for Tropical Agriculture (CIAT-TSBF) led a multi-institutional research study of mixed crop-livestock systems in Mozambique that evaluated smallholder intercropping of maize with pigeonpea and cowpea legumes. This intercropping practice provided farmers with improved surface cover of their fields, valuable N-fixing soil inputs, increased resilience to low rainfall conditions and better food security. (Rusinamhodzi, et al. 2011.)
- Ghanaian farmers surveyed by CIMMYT affirmed that they benefited from reduced risks as a result of their adoption of conservation agriculture. (Ekboir, et al. 2002.)

Truth # 7: Investing in conservation agriculture requires a long-term commitment to achieve widespread adoption.

- In Brazil, conservation agriculture is well-established practice, but it took a tremendous commitment first by early adopters, and then by government and extension agents to encourage widespread adoption. Local land user clubs were invaluable to changing farmers' mindsets by promoting the concept and helping each other in their conservation agriculture adoption efforts. The most innovative conservation agriculture farmers continually share their knowledge of best practices with their neighbors. They also share modifications to direct seeding equipment adapted to local soil crop residue conditions. (Bolliger et al.; Elsevier. 2006; and Ribiero, et al. 2007.)
- Catholic Relief Services' (CRS) conservation agriculture development project in Zimbabwe has been a multi-year effort to introduce farmers to conservation agriculture practices and support their adoption. An initial 650 farmers adopted conservation agriculture practices in the first year (2004/2005) and 54,416 farmers were practicing conservation agriculture at the end of five years. (Mutsindikwa, et al. 2011.)

Truth #8: Plants use synthetic fertilizer more efficiently when combined with conservation agriculture practices.

- A team of soil scientists assessed the efficiencies of improved crop yield gains with inorganic fertilizer inputs when applied to soils with higher levels of organic carbon. The study team concluded that "for efficient nutrient utilization, inorganic fertilizer must be combined with organic matter, water harvesting, conservation agriculture and controlling soil erosion in site-specific integrated soil fertility management strategies." Their recommendations clearly identify the important role of conservation agriculture practices enabling smallholder farmers to maximize the benefits of their use of synthetic fertilizer inputs. (Bationo, et al. 2006.)
- In the absence of conservation agriculture, if fertilizer use is stopped (because of lack of availability or affordability), production levels will likely fall, soil quality will not have been improved, and farmers will still lack the skills needed to sustainably build soil health to achieve long-term productivity. (Dorward, et al. 2008; and Jayne et al. 2009.)

Truth #9: Investment in farmer organizations helps farmers develop the skills and confidence to encourage and support the adoption of new practices like conservation agriculture.

- Cooperative groups of local farmers convincingly demonstrate best practices and serve as mentors to their peers. They are also better able to finance, purchase and share tools, exchanged improved seeds and agree to follow livestock management programs that protect residues and cover crops for uses that improve soil health and crop yields. Where local communities have been technically and organizationally developed, the eventual discontinuation of external assistance has not led to widespread farmer rejection of productive conservation agriculture practices. (Penning de Vries 2005.)
- It is critical to focus on enhancing farmer skills, knowledge and opportunities to directly participate in research and testing of techniques and technologies that best leverage local resources. By building farmers' individual and collective capacities to manage integrated conservation agriculture practices, their skills and experiences mature and they will become less reliant on remotely sourced inputs and provisions of external funding. (Agriculture at a Crossroads. IAASTD. Island Press. 2009.)

Truth #10: Smallholder farmers themselves must participate as partners in the research, development and demonstration efforts to advance conservation agriculture adoption.

- In the early 1990s, most maize and wheat farmers in the Yaqui Valley of Mexico were burning their crop residues. With the technical assistance of CIMMYT and other agricultural development organizations' field demonstrations of raised bed maize cultivation methods, improved irrigation techniques and mentoring support, in the span of one decade nearly all farmers had changed their practices and now retain their residues for soil conservation purposes. (Vehulst, et al. 2011.)
- In the span of forty years, Brazil has undergone a remarkable transition from relying on traditional and conventional tillage practices to today's condition where it is a major agricultural producer with 75% of cropland under no-till or reduced tillage. While this transformation substantially relied on innovating and expanding large scale farming operations, it also included adoption by hundreds of thousands of smallholder farmers. This farming revolution was accomplished with strong and persistent support from government and private sector investment in developing techniques, technologies and cropping practices to promote soil fertility and control erosion while producing profitable agricultural outputs. These efforts included focuses research programs, development and commercialization od no-till technologies, extensive field training and other initiatives. (Bolliger, et al. 2006.)

With long term investment, and a commitment to research, innovation, and developing a supportsystem to encourage the adoption of conservation agriculture, it is clear ther developing world can transform its approach to farming to be more productive and more sustainable for current and future generations.

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Jonna Jordan 2015

Effects of conservation agriculture on soils and natural resources

The Food and Agriculture Organization of the United Nations (FAO) defines CA as follows:

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes. CA is characterized by three principles which are linked to each other, namely:

- Continuous minimum mechanical soil disturbance;
- Permanent organic soil cover; and
- Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops (FAO 2007).

This article was drawn from previously published source entitled *Degradation of natural resources and measures for mitigation* by Theodor Friedrich. Refer to the source box towards the end of this article for a complete reference to the original article.

Editors note: This article though published in 2007, provides a good overview of a wide range of conservation technologies including a discussion of its relevance to climate change.

CA has the longest tradition and highest adoption rates in the southern cone of Latin America. In Paraguay, the area under conservation agriculture exceeds 50 per cent of the total agricultural land (Lange 2005). Also in Brazi,l about 50 per cent of the agricultural land is under CA. CA is further common in the USA and Canada. But also Australia, Central Asia, China, India and southern Africa have increasing areas under CA. Practical experiences with CA farming exist from areas close to the polar circle down to the tropics and for nearly all crops, including vegetables, roots and tubers. Despite the reduced tillage, CA must not be mistaken as low intensity agriculture. The same and often even higher yields can be obtained as in highly intensive conventional agriculture.

While the principles of CA are not new, the simultaneous application is creating the above mentioned synergy effects. Zero tillage reduces the mineralization of soil organic matter. In addition to this, the soil habitat remains undisturbed and soil life can develop in quantity and quality better than on tilled soils. Vertical continuous macro pores as created by earthworms or roots are not destroyed and remain as drainage channels for rainwater into the subsoil. By not disturbing the soil, the weed seed bank in the soil does not receive the stimulation for germination. This can be perfected even during the seeding process by furrow openers with minimum soil movement allowing the "invisible seeding". The permanent soil cover protects the soil surface from wind, rain, sun and from drying out.

In addition, the mulch suppresses the germination and growth of weeds, provides habitat for beneficial fauna and feed for the soil life and hence the substrate for the creation of soil organic matter. Allelopathic or other repellent effects of specific covercrops can be used for weed and pest management. The treatment of the mulch cover therefore is part of the weed management under CA. For this purpose, a knife roller is used to roll down and break covercrops and weeds without cutting them completely. Black oats (*Avena strigosa*), treated during the milky grain stage with a knife roller dies without the need of herbicides or desiccants. The mulch cover created by the knife-rolled black oats crop is so dense and has allelopathic effect that it inhibits any weed growth. Provided that during the seed process no soil is exposed to sunlight, a crop can be grown in this cover without the need of any further weed control (Friedrich 2005).

Crop rotation is of particular importance with regard to zero tillage and permanent soil cover. Different crop species with different root systems explore different soil horizons and hence increase the efficiency of the use of soil nutrients. In addition, a diversified crop rotation is beneficial for avoiding pest and weed problems. When designing the crop rotation, it is important that the entire growth period is used by growing some crop, if only for cover.

Also the other previously mentioned resource conserving technologies can be integrated into CA with beneficial complementarities. Direct seeding of rice facilitates the integration of the rice crop into a CA system with permanent zero tillage. The mulching reduces the problems of surface crusting and weeds. Controlled traffic farming is an important element of CA in mechanized farming, especially in humid climates where traffic in the field during crop protection or harvest operations cannot always respect the optimal soil conditions. In CA, it is particularly important to avoid compactions and wheel-tracks created by heavy machines, since those would oblige subsequent tillage operations which would destroy the structure built up in years of zero tillage. Surface irrigation requires some special care with the mulch management under CA. On the other hand, the effect of laser levelling remains longer under CA since the soil surface is not disturbed after the levelling. Even bed planting systems can be adapted for CA using permanent beds. This reduces the costs for the bed establishment and leads automatically to a controlled traffic system without the need of satellite guiding technology.

Conservation agriculture

The above described synergy effects have positive impact on productivity, efficiency of input use as well as on environmental effects and economic profitability of the production system. Soil erosion is reduced to a level below the regeneration of soil. In some cases, the soil is literally growing. Under humid temperate conditions the soil growth rate can amount up to 1 mm per year for 30 to 50 years, until the soil organic matter level reaches a new balance (Crovetto 1999). Depending on the supply of organic matter and climate conditions the increase of soil organic matter can reach 0.1-0.2 per cent per year. Soil structure is improved, soil volume available to root growth is increased, providing access to more soil nutrients and improving the fertilizer efficiency (Bot and Benites 2005). Continuous macro pores in the soil increase the water infiltration and hence the absorption capacity of soils during heavy rainstorms. This can be instrumental for the reduction of flood risks (DBU 2002).

The increased water infiltration contributes also to a recharge of the aquifer which is of particular importance for regions with falling ground water tables (PDCSR 2005). In view of the regular floods during the monsoon season in India and Bangladesh, during which large volumes of fresh water are lost without making use of them, and at the same time falling ground water tables in these regions, it would make sense to increase the infiltration capacity of the actually sealed rice soils by changing the cultivation practice. A better water infiltration does not only improve the availability of groundwater in a watershed, but also the water quality. Since the excess water is channelled in macro pores, it does not leach the soil. In addition the effectively reduced soil erosion provides for less fertilizer and pesticides being washed into surface waters. Watersheds with a wide application of CA report better water quality and reduced costs for the treatment of drinking water (Bassi 2000, Saturnino and Landers 2002).

The increased organic matter levels under CA also provide for better water retention capacity of the soil. For each percent of soil organic matter 150 m 3ha-1 of water can be stored in the soil. Loss of soil water is further reduced and in general water savings of 30 per cent under CA are reported compared to conventional cropping systems under similar climatic conditions (Bot and Benites 2005).

The visible increase of soil life and of fauna above the soil surface under CA can be taken as an indicator for an increased biodiversity of this cropping system. As a result, the ecosystem is more stable and less susceptible to pest attacks. This is also noticeable in a long term decline in pesticide use under CA (Saturnino and Landers 2002, Baker et al. 2007). Also higher fertilizer efficiency results last but not least from the increased soil life and is equally reflected in a long-term decline of fertilizer needs (Saturnino and Landers 2002, Derpsch 2005).

Climate change is becoming increasingly important for agriculture. Extended drought periods and heavy rainstorms are becoming common features of the weather not only in the tropics (Met Office 2005). CA can help to adapt to these changing and less stable climatic conditions. The increased water infiltration allows soils to absorb most of the rain water even during extreme rainfall events, reducing the risk of erosion and flooding (Saturnino and Landers 2002). Increased organic matter levels and a better rooting environment in the soil improve water holding capacity of the soils and the ability of plants to survive during drought periods.

Yield variations between dry and wet years are less pronounced under CA than under conventional farming practice (Shaxon and Barber 2003, Bot and Benites 2005).

In addition, agriculture can also help mitigate climate change by reducing the emissions of green house gases into the atmosphere. Since 40 per cent of the world's land surface is under agricultural use, the contribution of agriculture to climate change mitigation could be significant. CA can reduce the emissions of fossil fuels compared to conventional agriculture by up to 60 per cent (Doets et al. 2000). In addition to this , the use of fertilizer and agrochemicals can be reduced in the long term by 20 per cent.

CA would change the rice soils into a more aerobic environment without permanent flooding, which would reduce the methane emissions (Belder 2005; Gao 2006). Similar effects can be achieved for nitrous oxides as a result of changes in the nitrogen fertilizer and the soil water management. Suitable selection of fertilizers and placement in the soil can reduce the emissions also under conditions of zero tillage (Izaurralde et al. 2004; Gao 2006).

Conclusion

The actual degradation of natural resources is also a consequence of agricultural land use and as a result urges for changing the actual practices. The combination of several resource conserving technologies results in synergy effects leading to a sustainable, resourceenhancing agriculture which allows at the same time high productivity and profitability. This kind of agriculture is expanding under the term conservation agriculture. Besides being resource enhancing, productive and profitable, CA also helps in facing the challenges of climate change in agriculture and can contribute to mitigate against climate change. Technologies for CA exist globally but locally, the availability of suitable equipment and adapted knowledge may still be lacking being an obstacle for a more rapid adoption.

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Source: Degradation of Natural Resources and Measures for Mitigation

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Conservation practices to mitigate and adapt to climate change

Climate change, in combination with the expanding human population, presents a formidable food security challenge: How will we feed a world population that is expected to grow by an additional 2.4 billion people by 2050? Population growth and the dynamics of climate change will also exacerbate other issues, such as desertification, deforestation, erosion, degradation of water quality, and depletion of water resources, further complicating the challenge of food security. These factors, together with the fact that energy prices may increase in the future, which will increase the cost of agricultural inputs, such as fertilizer and fuel, make the future of food security a major concern. Additionally, it has been reported that climate change can increase potential erosion rates, which can lower agricultural productivity by 10% to 20% (or more in extreme cases). Climate change could contribute to higher temperatures and evapotranspiration and lower precipitation across some regions. This will add additional pressure to draw irrigation water from some already overexploited aquifers, where the rate of

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This article was drawn from an original article entitled *Conservation practices to mitigate and adapt to climate change* by Jorge A. Delgado, Peter M. Groffman, Mark A. Nearing, Tom Goddard, Don Reicosky, Rattan Lal, Newell R. Kitchen, Charles W. Rice, Dan Towery and Paul Salon. Refer to the source box towards the end of this article for a complete reference to the original article.

water recharge is lower than the withdrawal rates. These and other water issues exacerbated by climate change present a serious concern because, on average, irrigated system yields are frequently double those of non-irrigated systems.

The yields of non-irrigated systems could also potentially be reduced due to these stresses. Since there is a direct relationship between soil and water conservation practices and maintaining and/or increasing productivity, the research suggests that without the application of the best soil and water conservation practices, it will not be possible to maintain the productivity levels that are needed to feed the additional billions of people the world is expected to have by 2050. A sound scientific approach that applies concepts in agronomy, soil science, and conservation will be needed to maintain sustainable and productive agricultural systems for stable food security.

With so many large population centers of millions of people who need a steady supply of food, a supply that comes from agricultural fields, ranches, and other agro-ecosystems that could significantly be impacted by climate change, it is becoming increasingly accepted that systems maintain/increase agricultural productivity. Hugh Hammond Bennett, who has been called "the father of soil conservation," once said, "From every conceivable angle—economic, social, cultural, public health, national defense—conservation of natural resources is an objective on which all should agree" (USDA NRCS n.d.). Bennett's contributions were part of a larger effort to develop a scientifically sound conservation system, a system that today could serve as a framework not only for climate change mitigation but also for climate change adaptation.

This document is an overview of the science on conservation practices that could potentially be used to mitigate and adapt to climate change. Following is a list that summarizes some basic principles based on a review of peer-reviewed scientific publications. We recommend that these principles be considered, discussed, and even modified as new findings are brought to light that can be used to improve conservation. Meetings of professional scientific societies provide opportunities for scientists, conservation practitioners, consultants, farmers, and the general public to get together to share ideas and could be great forums for discussing the principles summarized in this document.

This review of current science strongly suggests that the future of the planet's food security will depend on how water and soil resources are managed today and in the future. These challenges can be met by maximizing soil and water conservation to develop sustainable systems essential to mitigate climate change and adapt to it.

Major world challenges related to soil and water conservation

From conducting a review of the scientific, peer-reviewed literature, we have identified the following major world challenges related to soil and water conservation:

- Climate change is occurring, and the implementation of sound conservation practices will be key for each country's health, social stability, and security. There are a large number of peer-reviewed publications that report on the effects of a changing climate. The potential role of conservation practices in contributing to food security is shown in figure 1, which illustrates the relationship between climate change, soil and water resources, and food security.
- Extreme weather events are creating environmental problems, accelerating the rate of erosion, and threatening agricultural production needed for food security. Increases in erosion rates due to climate change will result in lower productivity. Additionally, Hugh Hammond Bennett suggested that without conservation of natural resources, environmental problems such as accelerated erosion could negatively impact society and threaten national security (USDA NRCS n.d.).
- Population growth and the development of new, stronger economies, such as those of China and India are increasing the demand for world resource s. By 2050, the world population is expected to increase by 2.4 billion people, and as the economies of countries with large populations improve, even more pressure will be put on the world's agricultural systems. This increased demand for resources coupled with climate change could threaten the potential to achieve food security.
- Key world agroecosystems that rely on significant amounts of irrigation water are being threatened because water resources are being depleted, a result of water use exceeding water storage replacement. Since irrigated systems have, on average, double the yields of non-irrigated systems, the depletion and salinization of these key world resources results in additional pressure to increase agricultural productivity.

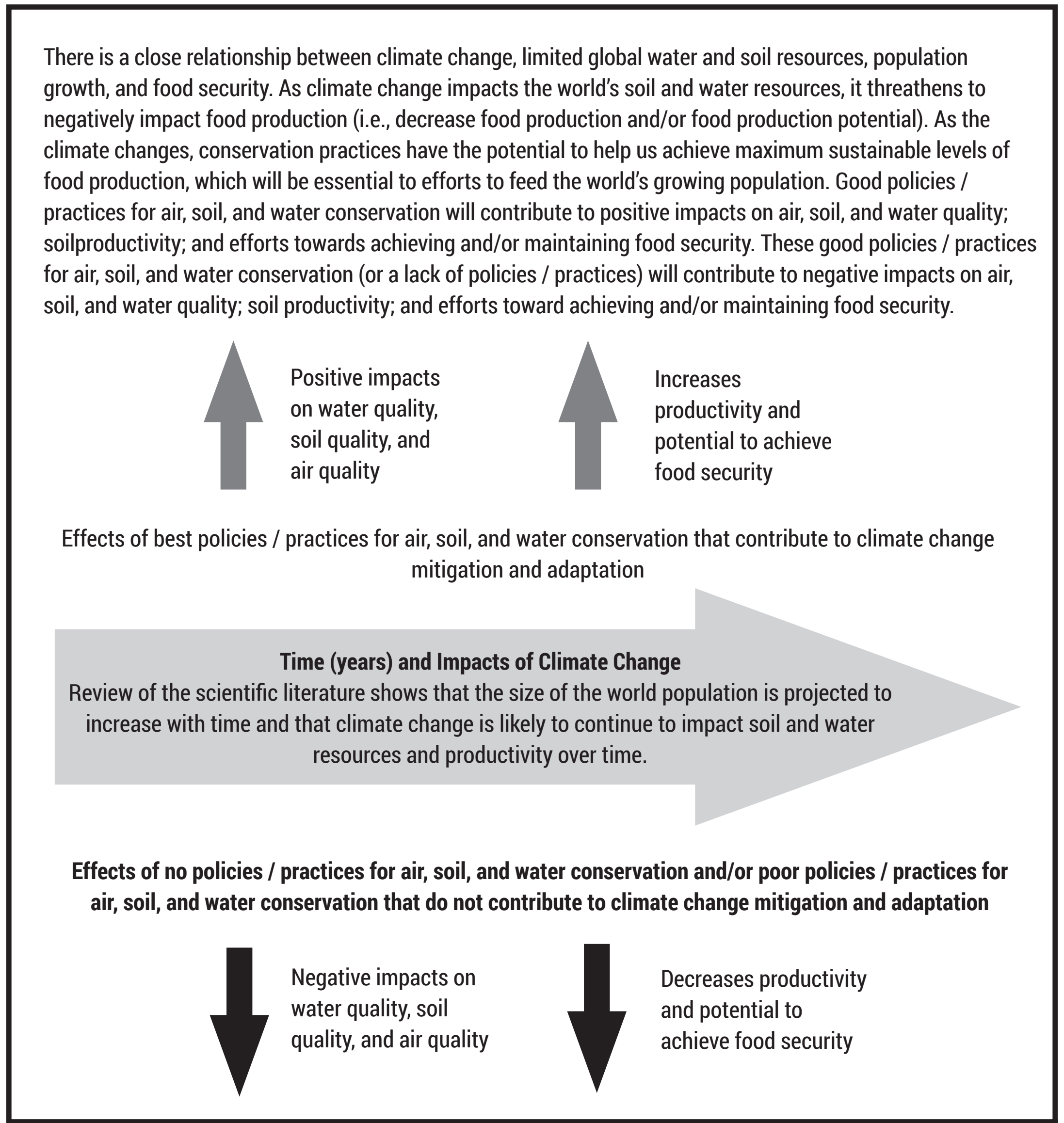

Figure 1. The potential role of conservation practices in contributing to food security.

Examples of Mitigation Strategies for Agricultural Production

1. Increasing soil C sequestration to improve soil functions
2. Reducing CH_4 emissions from ruminant with feeding management , use of edible oils, and possible vaccinations
3. Using slow-release N fertilizers with proper timing
4. Increasing N-use efficiencies for cropping systems
5. Capturing nutrients and energy from manure, crop residue, and cover crop management (close the nutrient cycles)
6. Using more efficient power sources and renewable energy (more efficient tractors, green power)

- Due to anticipated impacts from climate change, deforestation, erosion, depletion of water resources, and other environmental problems, as well as potentially higher fuel prices, which could impact agricultural inputs, food security will increasingly become a concern in the coming decades.

This could become an even greater concern if extreme events, such as droughts or floods, or even extreme pest or disease outbreaks (e.g., blight, a potato disease that contributed to the infamous potato famine in Ireland) begin to occur in systems that are already stressed.

It has been reported that GHGs emitted into the atmosphere by human activities have increase radiative forcing and caused an increase in the global mean temperature of approximately 0.74°C (1.33°F) over the past century. In terms of soil conservation, expected consequences of future climate change include changes to soil erosion rates and associated water quality problems, as well as the need to adjust the conservation planning process to meet continually changing rainfall intensities. It is important to apply conservation practices to conserve water quantity and quality (e.g. practices that have higher water-use efficiencies and/or that reduce off-site transport of soil and agrochemicals to water bodies). The threat of climate change, together with other concerns, could contribute to a global problem that will impact food security and resource availability if we do not act to prepare ourselves. Some of these concerns that can interact with climate change and extreme weather events are desertification, deforestation, depletion of groundwater resources, higher energy costs, plant diseases, and population growth and higher demand for food production. It is clear as we look ahead to the next four decades that we need to maximize agricultural production, due to the continuously growing food demand that comes with world population growth, while maximizing soil and water conservation.

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Source: Conservation practices to mitigate and adapt to climate change

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by: Jorge A. Delgado, Peter M. Groffman, Mark A. Nearing, Tom Goddard, Don Reicosky, Rattan Lal, Newell R. Kitchen, Charles W. Rice, Dan Towery, and Paul Salon
The original document provides an excellent overview of the science on conservation practices that could be potentially used to adapt and to mitigate climate change. However in this excerpt only the portion related to the major challenges related to soil and water conservation and climate change are introduced and the conclusions summarized. For details on the basic principles please refer to the original document

www.swcs.org
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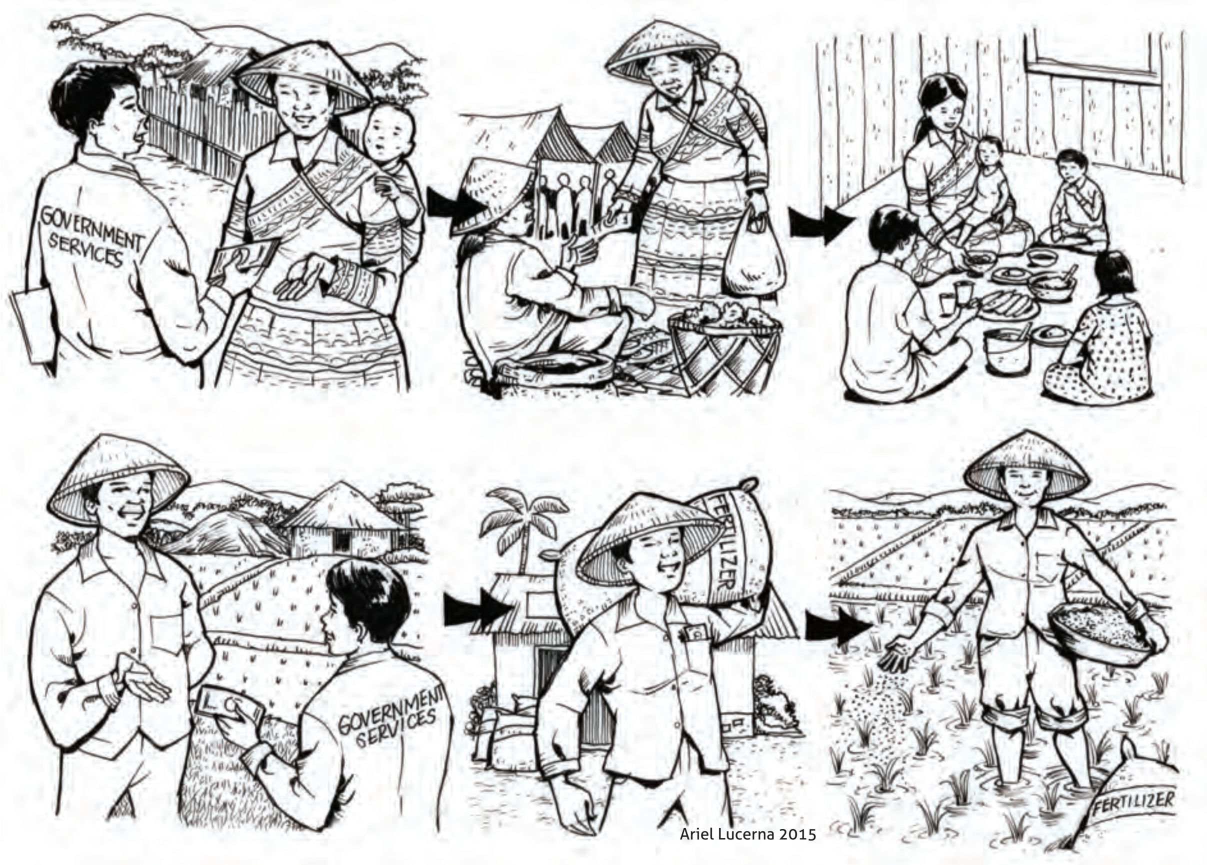
chapter 5

Social protection and services responding to climate shock

- Social protection and its linkage to agriculture
- Linking climate change adaptation and disaster risk reduction
- Adaptation to climate change in the context of sustainable development and equity
- Rethinking resilience: Social protection in the context of climate change
- Women adapting to climate change
- Gender differentiated impacts of climate change
- Gender and climate change
- Small-scale farmer innovation systems
- Social protection and agriculture to break the cycle of rural poverty

Social protection & services responding to climate shock

This chapter examines the role of social protection measures for the most vulnerable and poorest people of society, who do not have financial and other resources to combat the negative impacts of climate change. This includes agricultural support systems to break the cycle of rural poverty and build agricultural resilience to better manage community adaptation to climatic shocks. It tackles frameworks for managing vulnerability, especially related to gender, since women are considered at special risk. For example, women are more likely to lose their lives in flooding or mud slides since they often farm the most vulnerable land. The chapter evidences disparities between men's and women's access to and control over key assets - especially resources related to agricultural production, and outlines necessary adaptation measures to tackle these and other social challenges and inequalities.



Social protection and its linkage to agriculture

The Millennium Development Goals (MDGs) on reducing poverty have been met by many countries, yet many others lag behind and the post-2015 challenge will be the full eradication of poverty and hunger. Many developing countries increasingly recognize that social protection measures are needed to relieve the immediate deprivation of people living in poverty and to prevent others from falling into poverty when a crisis strikes. Social protection can also help recipients become more productive by enabling them to manage risks, build assets and undertake more rewarding activities. These benefits spread beyond the immediate recipients to their communities and the broader economy as recipients purchase food, agricultural inputs and other rural goods and services. But social protection can only offer a sustainable pathway out of poverty if there is inclusive growth in the economy. In most low- and middle-income countries, agriculture remains the largest employer of the poor and is a major source of livelihoods through wage labour and own production for household consumption and the market. Poverty and its corollaries—malnutrition, illness and lack of education—limit agricultural productivity. Hence, providing social protection and pursuing agricultural development in an integrated way offers synergies that can increase the effectiveness of both.

This article was repackaged from the original article entitled *The State of Food and Agriculture Social protection and agriculture: Breaking the cycle of rural poverty* by the Food and Agriculture Organisation of the UN. Refer to the source box towards the end of this article for a complete reference to the original article.

Trends in poverty

Although the shares of people living in poverty and extreme poverty have declined over the past three decades, the numbers remain high, with almost one billion people considered extremely poor and another billion poor. Extreme poverty has fallen substantially in many regions, especially in East Asia and the Pacific as well as in South Asia. In sub-Saharan Africa, little progress has been made and almost half the population is extremely poor.

Extreme poverty is disproportionately concentrated in rural areas, and the rural poor are more likely to rely on agriculture than other rural households, especially in sub-Saharan Africa. It is the poor's reliance on agriculture for their livelihoods and the high share of their expenditure on food that makes agriculture key to poverty and hunger alleviation interventions.

Why is poverty so persistent?

Poverty often begins with poor nutrition and health, especially in early childhood: the poor become trapped in vicious circles of hunger, poor nutrition, ill health, low productivity and poverty. Economic growth, especially agricultural development, has been essential for driving down poverty rates. However, even with economic growth, the struggle to escape from poverty is often slow as growth may not be inclusive. For some groups, such as children and the elderly, economic growth may bring little relief or come too late to prevent deprivation and lasting disadvantage.

The pathway out of poverty is difficult. In addition, many non-poor households are vulnerable to poverty when faced with shocks of one kind or another. These shocks cause many households to fall below the poverty line because they suffer large income losses and do not have sufficient savings to buffer the shocks. Such shocks typically have long-lasting negative impacts on the poor.

What is social protection?

Social protection encompasses initiatives that provide cash or in-kind transfers to the poor, protect the vulnerable against risks and enhance the social status and rights of the marginalized—all with the overall goal of reducing poverty and economic and social vulnerability. Social protection includes three broad components: social assistance, social insurance and labour market protection. Social assistance programmes are publicly provided conditional or unconditional cash or in-kind transfers or public works programmes. Social insurance programmes are contributory programmes that provide cover for designated contingencies affecting household welfare or income. Labour market programmes provide unemployment benefits, build skills and enhance workers' productivity and employability.

Social protection programmes have expanded rapidly over the past two decades. Throughout the developing world, about 2.1 billion people, or one-third of the population, receive some form of social protection. There is wide variation among regions, with coverage lowest in the regions where poverty incidence is highest. This report focuses on social assistance, by far the most common form of social protection in the developing world.

Is social protection affordable?

Most countries, even the poorest, can afford social protection programmes that could be of significance in the fight against poverty. Spending on such programmes has been low relative to GDP. For more comprehensive programmes, financing may require difficult expenditure choices. Donor support will be essential in the short-to-medium term for maintaining programmes in some countries. Yet, mobilizing domestic fiscal resources from the outset are important in principle and to establish a politically and financially sustainable basis for social assistance programmes. Pilot programmes and careful monitoring and evaluation can help start the policy dialogue needed to build a national consensus on the nature, scale and financing of social assistance within a country.

Social protection can help reduce poverty and food insecurity

Social protection programmes are effective in reducing poverty and hunger. In 2013, social protection helped lift up to 150 million people out of extreme poverty, that is, those living on less than $1.25 a day. Social protection allows households to increase and diversify their food consumption, often through increased own production. Positive impacts on child and maternal welfare are enhanced when programmes are gender-sensitive or targeted at women. This is especially important because maternal and child malnutrition perpetuate poverty from generation to generation.

Increased food consumption and greater dietary diversity do not automatically lead to improved nutrition outcomes. Nutritional status depends on a number of additional factors, including access to clean water, sanitation and health care, as well as appropriate child feeding and adult dietary choices. Thus, for social assistance programmes to improve nutrition outcomes, they must be combined with complementary interventions. Numerous agricultural interventions, such as home gardening and small livestock breeding, can also contribute to improving nutrition.

The potential impact of social protection on investment and growth

The livelihoods of most poor rural households in the developing world are still based on agriculture, particularly subsistence agriculture. Many of these farmers live in places where markets—for agricultural inputs and outputs, labour, and other goods and services such as credit and insurance—are lacking or do not function well. The uncertainties of weather, particularly with accelerating climate change and the lack of affordable insurance, are at the heart of the vulnerabilities of households dependent on agricultural livelihoods.

The time horizon of vulnerable agricultural households is reduced because they focus on survival. As a result, they are especially prone to adopt low-risk, low-return agricultural and other income-generating strategies, and may seek to obtain liquidity or diversify income sources in casual labour markets. For similar reasons, households may underinvest in the education and health of their children, as well as adopt negative risk-coping strategies such as distress sales of assets, reducing the quantity and quality of food consumption, begging or taking children out of school, and exploiting natural resources in an unsustainable manner.

Social protection can positively influence the investment decisions of poor households. It helps households manage risk. Social protection provided at regular and predictable intervals can increase predictability and security for agricultural households, partially substituting for insurance and providing a crucial source of liquidity. A growing body of evidence shows that social assistance programmes not only prevent households from falling into deeper poverty and hunger when exposed to a shock but, by helping the poor overcome liquidity and credit constraints and manage risks more effectively, it also allows them to invest in productive activities and build assets. The evidence shows that social protection fosters more investment in the education and health of children, and reduces child labour, with positive implications for future productivity and employability. When well implemented, social protection can also facilitate increased investment in farm production activities, including inputs, tools and livestock, as well as in non-farm enterprises. Even relatively small transfers help the poor overcome liquidity and credit constraints and provide insurance against some risks that deter them from pursuing higher-return activities. The evidence is clear that transfers also foster greater inclusion by facilitating poor households' participation in, and contribution to, social networks, which help households cope with risk and play a supportive role in the social fabric of communities.

Social protection does not reduce work effort. But it does give beneficiaries greater choice, and many shift time previously dedicated to casual agricultural wage employment of last resort to own-farm work or non-farm employment. Taken together with the increase in farm and non-farm production activities, social protection strengthens livelihoods rather than fostering dependency.

Social protection has positive impacts on local communities and economies. Public works programmes can provide important infrastructure and community assets and, when designed and implemented properly, contribute directly to the local economy. Cash transfers increase the purchasing power of the poor, who demand goods and services largely produced in the local economy. Moreover, such additional income contributes to a virtuous circle of local economic growth. Complementary programmes may be necessary to reduce supply-side constraints, thus preventing significant price rises and increasing the real-income and production impacts of the programme.

Understanding what works: implications for programme design and implementation

Not all programmes are equally effective, and their impacts can vary greatly, both in size and in nature. Even among programmes that appear quite similar, for example cash transfers for the poor, differences in programme design and implementation can lead to very different outcomes. For example, targeting households with fewer adults of working age will have implications for labour impacts on livelihoods.

Targeting can help achieve programme objectives at lower costs

Social protection programmes generally have objectives that define the intended beneficiaries. How well programmes can achieve their objectives will depend, among other things, on how well they reach their target group. Social protection programmes use a combination of targeting methods to deliver larger and better transfers to selected individuals or households. While targeting can be an effective instrument for reducing poverty and inequality, efficient implementation is key and depends largely on institutional capacity.

Level, timing and predictability of transfers matter

Most social assistance transfers are designed to cover the cost of a minimum basket of food consumption; so, if additional impacts are sought, then transfer levels should be increased accordingly. The available data show a wide variety of transfer levels, with many countries providing average social protection transfers to beneficiaries several times greater than the poverty gap (at $1.25 a day), while in many of the poorest countries transfers are well below what it would take to close the gap.

Just as important, perhaps, are the timing and predictability of transfers. Beneficiary households will spend irregular lump sum transfers differently than they would predictable and regular transfers. If transfers are not regular and reliable, it is difficult or households to plan and smoothen consumption over time, and thus move towards sustained change in the quantity and quality of diets. Moreover, regularity and reliability increase the time horizon of beneficiary households, allowing them to manage risks and shocks more effectively and thus avoid "negative" coping strategies and risk-averse production strategies and, instead, increase risk-taking in more profitable crops and/or activities. Regular and reliable payments increase confidence and creditworthiness, while reducing pressure on informal insurance mechanisms.

Household-level factors and gender influence programme impacts

Targeting criteria have strong implications for the demographic characteristics of beneficiary households, such as age of adults and children, which condition the impact of the programme. Households with more available labour, for example, are in a better position to take advantage of the cash for productive investments, in both the short and longer run.

Women and men use transfers differently. Many social protection programmes target women because research shows that giving women greater control over household spending leads to greater expenditures on food, health, education, children's clothing and nutrition. In addition, studies show that the impacts of transfer programmes vary with gender. For example, women and men may not invest in the same type of livestock: women generally focus on small animals while men focus on larger livestock. Transfers also impact men and women, and boys and girls, differently in terms of labour allocation and time use.

Markets matter too

The nature of the local economy also shapes the type and extent of the prospective productive impacts of cash transfer programmes. In some rural areas, low population density, illiquid markets, low levels of public investment and inadequate public infrastructure can pose particularly binding constraints and make in-kind transfers more effective. Where markets are more developed, the effects of cash transfers on livelihood strategies tend to be stronger. The importance of market conditions varies with available factors of production.

Social protection and agricultural development

Notwithstanding its proven effectiveness, social protection alone cannot sustainably move people out of poverty and hunger. Agriculture and social protection are fundamentally linked in the context of rural livelihoods. Poor and food-insecure families depend primarily on agriculture for their livelihoods, and make up a large proportion of the beneficiaries of social protection programmes. Stronger coherence/between agriculture and social protection interventions can help protect the welfare of poor, small-scale agriculturalists, helping them manage risks more effectively and improve agricultural productivity, leading to more sustainable livelihoods and progress out of poverty and hunger.

However, relatively few agricultural interventions are coordinated or integrated with social protection programmes. Developing synergies is an opportunity, but also a necessity, because of the difficult public expenditure trade-offs implied by constrained government budgets. It is not only imperative to help the poorest meet basic consumption needs, especially when they are unable to work, but such help is itself a foundation for gradual improvement of the livelihoods of the poor. Leveraging public expenditures on agriculture and social protection programmes in support of each other not only furthers this transformation, but also strengthens agricultural and rural development.

Options for combining agricultural policies with social protection

A continuum of options exists for bringing together and better coordinating social protection and agricultural interventions and policy. These options range from stand-alone, sector-specific social protection or agricultural programmes, which are designed to bring the two together in integrated results in both sectors, to joint programmes in which formal interventions of both types are brought to bear on specific target populations, and to sectoral interventions that are aligned to maximize complementarities and reduce contradictions. Approaches can be combined or sequenced in a variety of ways.

Social protection and agricultural input subsidies

Input subsidies, in particular fertilizer subsidies, have regained widespread popularity in Africa, Asia, and Latin America and the Caribbean, especially following the sharp increases in food prices and fertilizer costs in 2007-08. Insofar as input subsidy programmes contribute to greater food security through greater availability and lower prices of staple goods, they also benefit the poor, and are aligned with and contribute to the objectives of social protection policies and programmes. But, in general, such programmes neither target nor reach the poor.

Fertilizer subsidy programmes absorb a large part of government agricultural budgets in many countries. Linkages of these single "stand-alone" input programmes with social protection could include improving the reach of input subsidies to the poorest households by, for instance, improving targeting and/or adjusting the size and type of input packages to the specific needs of the poorest small family farmers. Targeting the poorest is best achieved through input packages designed to meet their actual needs. Another option is to combine these programmes with social cash transfer programmes that provide the poorest beneficiaries with the additional liquidity needed to pay for the "unsubsidized" part of the input.

Credit to agriculture

Credit constraints are a major barrier to agricultural investment. Relatively little credit is allocated to agriculture and many agricultural producers are credit-constrained. In many countries, addressing credit market failures—through special programmes, credit guarantee schemes and specialized banks—is a priority. Nearly all Asian, Latin American and Caribbean countries, and a majority of African countries, are taking measures to facilitate the provision of credit to the agriculture sector.

Directly targeting the poorest with (micro) credit has proven difficult. There is increasing evidence that, on its own, microcredit is not sufficient to help poor households exit poverty or to improve their welfare as measured by consumption, health, education and women's empowerment.

Institutional procurement programmes

Lack of adequate markets is an important limiting factor on agricultural growth and rural development. So-called institutional procurement programmes (IPPs) promote rural development by creating a market for small family farm produce. Interventions that link social assistance with institutional demand also typically focus on supporting poorer small family farmers who are constrained in their access to resources.

Brazil was the first country to develop an institutional food procurement programme by connecting development of guaranteed demand for small family farm produce with a food security strategy. The Brazilian experience is being adapted to the African context through the Purchase from Africans for Africa programme. Home-grown school-feeding programmes, sometimes building on the Purchase for Progress (P4P) programme of the World Food Programme (WFP), are an example of IPPs that are popular in many countries.

Bringing the sectors together: the critical issue of targeting

A fundamental operational issue to be addressed in bringing the sectors together is targeting interventions. The experience of several countries shows that single or unified registries or unified targeting systems are particularly useful if several programmes have overlapping objectives and target populations.

While the effectiveness of specific programmes is served by better targeting, this need not contradict the universal provision of some form of social protection to all vulnerable people when they need it to avoid long-lasting harm from external shocks.

Key messages of the report

- Social protection programmes reduce poverty and food insecurity. Effective targeting and adequate transfers are important determinants of success. Social protection contributes to higher incomes and food security not only by ensuring increases in consumption, but by enhancing a household's ability to produce food and augment income.

- Programmes targeted at women have stronger food security and nutrition impacts. Programmes that are gender-sensitive, reduce women's time constraints and strengthen their control over income enhance maternal and child welfare. This is especially important because maternal and child malnutrition perpetuate poverty from generation to generation.
- Social protection stimulates investment in agricultural production and other economic activities. Social protection enhances nutrition, health and education, with implications for future productivity, employability, incomes and well-being. Social protection programmes that provide regular and predictable transfers promote savings and investment in both farm and non-farm activities, and encourage households to engage in more ambitious activities offering higher returns.
- Social protection does not reduce work effort. But it does give beneficiaries greater choice, and many shift time previously dedicated to casual agricultural wage employment of last resort to own-farm work or non-agricultural employment. Taken together with the increase in farm and non-farm production activities, social protection strengthens livelihoods instead of fostering dependency.
- Social protection has virtuous impacts on local communities and economies. Public works programmes can provide important infrastructure and community assets and, when designed and implemented properly, contribute directly to the local economy. Cash transfers increase the purchasing power of beneficiary households, who demand goods and services, many of which are produced or provided in the local economy by non-beneficiary households. Complementary programmes may be necessary to reduce production constraints to prevent inflation and maximize the real-income and production impacts of the programme.
- Social protection, by itself, is not enough to move people out of poverty. As poor households typically face multiple constraints and risks, joint, coordinated and/or aligned social protection and agricultural programmes are likely to be more effective in helping poor households move out of poverty in a sustainable manner.
- There are clear opportunities to leverage social protection and agriculture programmes to further rural development. Developing synergies is an opportunity and also a necessity because of constrained government budgets. It is imperative to help the poorest meet basic consumption needs, especially when they are unable to work. Such help can itself become a foundation for gradual improvement of the livelihoods of the poor. Given that the majority of the rural poor depend largely on agriculture, agricultural interventions are needed to overcome structural supply-side bottlenecks holding back growth. Leveraging public expenditures on agriculture and social protection programmes in support of each other not only furthers this transformation, but also serves to strengthen agricultural and rural development.
- A national vision is needed of how agriculture and social protection can gradually move people out of poverty and hunger. National vision and commitment, supported by permanent domestic resource mobilization, must support coordinated action at the national and subnational levels. Policy and planning frameworks for rural development, poverty reduction, food security and nutrition need to articulate the role of agriculture and social protection in moving people out of poverty and hunger, together with a broader set of interventions. The type of agricultural interventions combined with social assistance depends on the context and constraints, but must also consider issues such as local implementation capacities and available resources. In all cases, interventions must be designed to address a range of constraints to allow the poorest to transform their livelihood strategies to escape and remain out of poverty.

Source: The State of Food and Agriculture: Social protection and agriculture: breaking the cycle of rural poverty

By: Food and Agriculture Organization of the United Nations, Rome 2015

Jonna Jordan 2015

Linking climate change adaptation and disaster risk reduction

Introduction

As global climate change escalates, the risk of floods, droughts and severe storms increases. In its 4th Assessment Report, the Inter-governmental Panel on Climate Change (IPCC) projects that rising global temperature will cause increasing drought in mid-latitudes and semi-arid latitudes, increased water stress in many parts of the world, increased damage from storms, and coastal flooding affecting millions more people each year (IPCC 2007). With 94 per cent of disaster-related deaths occurring in developing countries (Mathur et al 20014), the outlook for poor people is bleak.

Climate change increases disaster risk in a number of ways. It changes the magnitude and frequency of extreme events (meaning that coping and response mechanisms and economic planning for disasters based on past vulnerabilities may no longer suffice) (Sperling and Szekely 2005). It changes average climatic conditions and climate variability, affecting underlying risk factors, and it generates new threats, which a region may have no experience

This article was drawn from previously published materials entitled *Linking climate change adaptation and disaster risk reduction* witten by Paul Venton and Sarah La Trobe of Tear Fund, IDS. Refer to the source box towards the end of this article for a complete reference to the original article.

Editors note: This article was written in 2009. Though current emphasis is on resilience-building (doing DRR and CCA together), this article is still considered very relevant to those settings where the DRR and CCA divide still remains.

in dealing with. Clearly, the climate change and disaster management communities need to work together in addressing these issues. If climate change adaptation policies and measures are to be efficient and effective they must build on and expand existing DRR efforts. And if DRR approaches are to be sustainable they must account for the impact of climate change.

To date, the climate change and disaster management communities have operated largely in isolation from each other. This situation must change as a matter of urgency. Between 2008 and 2009, governments are negotiating under the UNFCCC on the second commitment period of the Kyoto Protocol, to begin in 2012 (referred to as the 'post-2012 framework'). Climate change adaptation is one of four pillars of this framework. DRR must be a key component of the adaptation pillar if an effective, sustainable approach to adaptation is to be achieved.

This paper is primarily aimed at climate change and disaster risk management policy/decision makers at local, national and international levels. Its purpose is to raise awareness of the similarities and differences between climate change adaptation and DRR, to highlight the benefits of a more integrated approach to these issues, and, ultimately, to increase the level of strategic co-ordination between the climate change and disaster risk management communities. This could result in the following benefits:

1. Reduction of climate-related losses, through more widespread implementation of DRR measures linked with adaptation.
2. Increased effectiveness and sustainability of both adaptation and DRR approaches.
3. More efficient use of financial, human and natural resources.

In section 1, we describe similarities and differences between adaptation and DRR. In section 2, we discuss the rationale for adopting a more integrated approach to adaptation and DRR. In section 3, we propose recommendations to improve co-ordination and collaboration between the climate change and disaster risk management communities at all levels.

Similarities and differences

Similarities

Similar aims The IPCC defines climate change adaptation as: 'An adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits benefit opportunities'.

Disaster risk reduction can be defined as: 'The broad development and application of policies, strategies and practices to minimise vulnerabilities and disaster risks throughout society, through prevention, mitigation and preparedness' (Twigg 2004).

While their scope and specific interests may differ, adaptation and DRR have very similar aims in terms of seeking to build resilience in the face of hazards. They both focus on reducing people's vulnerability to hazards by improving methods to anticipate, resist, cope with and recover from their impact. In so doing, climate change adaptation clearly focuses on climate-related hazards, such as floods, droughts and storms. The disaster risk management community has a long history of dealing with such events, and therefore a wealth of experience relevant to adaptation.

Importantly, both adaptation and DRR seek to build resilience to hazards in the context of sustainable development. Climate change adaptation requires the re-shaping and re-designing of development, social and economic practices to respond effectively to new or anticipated environmental changes. Likewise DRR seeks to influence development decision-making and protect development aspirations from environment-related risks. The effectiveness of both adaptation and DRR are limited if they are not viewed within the broader context of sustainable development.

The World Resources Institute (WRI) presents a model of adaptation which helps to illustrate how closely DRR is linked with adaptation. The WRI frames adaptation as a 'continuum of responses to climate change', divided into four types of adaptation efforts, ranging from 'pure' development activities at one end of the continuum to very explicit adaptation measures at the other. The four types of adaptation are:

1. Addressing the drivers of vulnerability (i.e. factors making people vulnerable to harm).
2. Building response capacity (laying the foundation for more targeted actions).
3. Managing climate risk (reducing the effects of climate change on resources/livelihoods).
4. Confronting climate change (highly specialised activities, such as relocating communities in response to sea level rise).

While DRR measures typically fall under the middle two categories of building response capacity and managing climate risk, they can fit into every category of the adaptation continuum, addressing drivers of vulnerability (e.g. diversifying livelihood strategies in flood-prone areas) as well as confronting climate change (e.g. reducing the risk of glacial lake outburst floods).

Mutual benefits

In seeking to reduce vulnerability to hazards, the disaster risk management community implements a variety of measures which support adaptation in two ways: (1) through reducing climate-related disaster risk, and (2) in offsetting the long-term implications of climate change. For example, with regards to the latter point:

- reforestation (a key 'DRR' measure) will lessen the impact of a flood, but will also offset long-term soil degradation and help control local temperature and rainfall.
- improvements to the health sector in developing countries will help safeguard health in times of flood and where there is lack of clean, safe drinking water and increased numbers of mosquitoes as a result of climate change.
- better management and conservation of water resources in a region of vulnerability will offset drought and moderate longer-term water scarcity.

In the same way that DRR supports adaptation, measures more typically associated with adaptation to climate change such as addressing the impact of glacial retreat or salt water intrusion onto agricultural land, will support DRR through reducing long-term vulnerability and influencing development potential.

With similar aims and mutual benefits, the relevance of DRR to the design and implementation of adaptation policies and measures cannot be over-emphasised. As Sperling and Szekely state, *'To be effective, efforts to respond to the exceptional challenges posed by a changing climate must build on and expand the existing capability of disaster risk reduction, and should not be undertaken in isolation from this wider agenda'* (Sperling and Szekely 2005). The disaster risk management community not only has transferable, practical experience in addressing hazards, it also has strong and well-established local and regional institutions which are currently lacking in the field of adaptation.

Non-structural measures

Non-structural measures refer to policies, knowledge development/awareness and methods and operating practices, including participatory mechanisms, which can reduce risk and related impacts. These non-structural measures are well placed to serve both a DRR and a climate change adaptation agenda. The dynamism associated with training and awareness-raising means that people and institutions can apply skills and knowledge in different circumstances as they emerge. For example, awareness-raising as a component of an early warning system to cope with current flood risks is well placed to form an effective basis under a different future flood scenario.

Poverty reduction and underlying risk

Both climate change and disaster risk management communities recognise and accept that the poor are disproportionately affected by hazards. This is due to a lack of access to the means by which they can improve their resilience, whether this is in economic, social, physical, or environmental terms. So for both adaptation and DRR, poverty reduction and sustainable natural resource management are essential components of reducing vulnerability to hazards and climate change (Thomalla et al. 2006).

In seeking to increase poor people's resilience to climate change and disasters, enabling local communities to participate in adaptation and DRR decision-making is crucial. Such an approach has long underpinned community-based disaster risk management. This approach must also underpin adaptation efforts, if adaptation is to be effective at the local level where impacts are most acutely felt.

Addressing underlying risk factors is critical for effective poverty and vulnerability reduction. Underlying risk relates to the interaction of a range of factors including globalisation processes, demographic trends, economic development and trade patterns, urbanisation, discrimination and limited local and national government capacity, which have an impact on exposure and vulnerability to hazards. In this context, all local and global issues that change risk patterns and increase vulnerabilities are relevant to adaptation and DRR (Sperling and Szekely 2005).

In principle, both adaptation and DRR aim to address such macro-level influences. However, in practice, perspectives on underlying risk do not yet go deep enough into the social, economic and political realms where risk is generated for the poor and most vulnerable. As such, a shared challenge for the climate change and disaster risk management communities is ensuring that adaptation and DRR commonly address root causes of risk, not merely symptoms.

Mainstreaming

It is increasingly recognised that adaptation and DRR must be integral components of development planning and implementation, to increase sustainability. In other words, these issues need to be 'mainstreamed' into national development plans, poverty reduction strategies, sectoral policies and other development tools and techniques. At the World Conference on Disaster Reduction in 2005, governments agreed to adopt a mainstreamed approach to DRR. To date there has been no such formal international-level agreement on mainstreaming adaptation. However, in 2005 the Commission for Africa made a significant recommendation that 'donors make climate variability and climate change risk factors an integral part of their project planning and assessment by 2008'.

In seeking to mainstream adaptation and DRR, both communities are faced with mainstreaming-related dilemmas. For example, an emerging problem is 'mainstreaming fatigue'. Mitchell and Collender suggest that mainstreaming fatigue 'must ... be tackled by creating positive and recognisable goals, and avoiding replication with other parallel processes' (Mitchell and Collender 2007).

Converging political agendas

DRR is strongly associated with present day conditions. Since the 2001 Marrakesh Accords, adaptation also acknowledges existing conditions as its starting point (although there is still a misconception regarding the relevance of adaptation to present day conditions). Tanner states, 'The basis for adapting to the future climate lies in improving the ability to cope with existing climate variations (Tanner 2007). By improving the capacity of communities, governments or regions to deal with current climate vulnerabilities, for instance through existing DRR activities, their capacity to deal with future climatic changes is likely to improve.

In the policy debate on climate change there has been growing recognition of the importance of adaptation, and within this, the need to improve the capacity of governments and communities to address existing vulnerabilities to current climate variability and climatic extremes. This development has taken place in parallel to the shift from disaster management to disaster risk management, which is adopting a more anticipatory and forward-looking approach (Thomalla et al. 2006). Climate change adaptation and DRR, therefore, have merging remits and highly significant converging political agendas.

This was evident at the World Conference on Disaster Reduction (WCDR) held in Kobe, Japan in 2005 as well as more recently at the 13th session of the UNFCCC Conference of the Parties (COP 13) held in Bali in December 2007. At the WCDR, governments agreed that risk reduction associated with climate change should be incorporated into DRR and adaptation strategies. At COP 13, governments formally recognised the importance of DRR for adaptation in the Bali Action Plan, agreeing that 'Enhanced action on adaptation' should include consideration of 'disaster reduction strategies'.

Differences

Hazard types Climate-related, or 'hydro-meteorological' hazards only represent one type of hazard dealt with by the disaster management community. The full range of hazards that DRR can encompass includes natural (e.g. geological, hydro-meteorological and biological) or those induced by human processes (e.g. environmental degradation and technological hazards). Therefore, DRR expands beyond the remit of climate change adaptation (see Figure 1).

Similarly, climate change adaptation moves outside the realm of most DRR experience, to address longer term impacts of climatic change such as loss of biodiversity, changes in ecosystem services and spread of climate-sensitive disease. These issues are typically positioned at the far end of the WRI's adaptation continuum, and are less likely to be addressed by the DRR community.

Both the climate change and disaster risk management communities must recognise that adaptation and DRR have these more exclusive elements, to avoid perpetuating the erroneous view that all adaptation and DRR is the same. However, recognition of exclusive elements should not detract from efforts to develop a more integrated approach, as the majority of adaptation and DRR measures have mutual benefits, offsetting both climate and disaster-related risks.

Time scale Thomalla observes that much of the difference between adaptation and DRR relates to a different perception of the nature and timescale of the threat: Disasters caused by extreme environmental conditions tend to be fairly distinct in time and space (except for slow-onset or creeping disasters like desertification) and present a situation where the immediate impacts tend to overwhelm the capabilities of the affected population and rapid responses are required. For many hazards there exists considerable knowledge and certainty about the event characteristics as well as exposure characteristics based on historical experiences. Most impacts of climate change, meanwhile, are much more difficult to perceive and measure, since the changes in average climatic conditions and climatic variability occur over a longer period (Thomalla et al. 2006).

DRR focuses on reducing foreseeable risks based on previous experience, whereas adaptation originates with environmental science predicting how climate change will be manifested in a particular region over a longer time period. Consequently DRR is more likely to struggle to integrate risks that have yet to be experienced, whereas this is a core component of an adaptation strategy with its focus on shifting environmental conditions (Few et al. 2006). However, according to Sperling et al, DRR is increasingly incorporating scientific advances and consequently is gaining a longer-term perspective (Sperling and Szekely 2005). Indeed it must, if DRR measures are to be sustainable in the face of climate change.

Level of significance placed on existing capacities

Building resilience is a basis for both DRR and climate change adaptation. However, for DRR the emphasis is on determining existing capacity so as to anticipate, resist, cope with and recover from the impact of hazards. 'Traditional knowledge' on such matters is therefore an important starting point for developing DRR strategies. However, 'traditional knowledge' may be limited in its effectiveness at dealing with an exacerbation of existing problems, or with 'non-traditional problems', such as those to be experienced for the first time through climate change. A blend between traditional knowledge and an understanding of the projected impacts of climate must be sought.

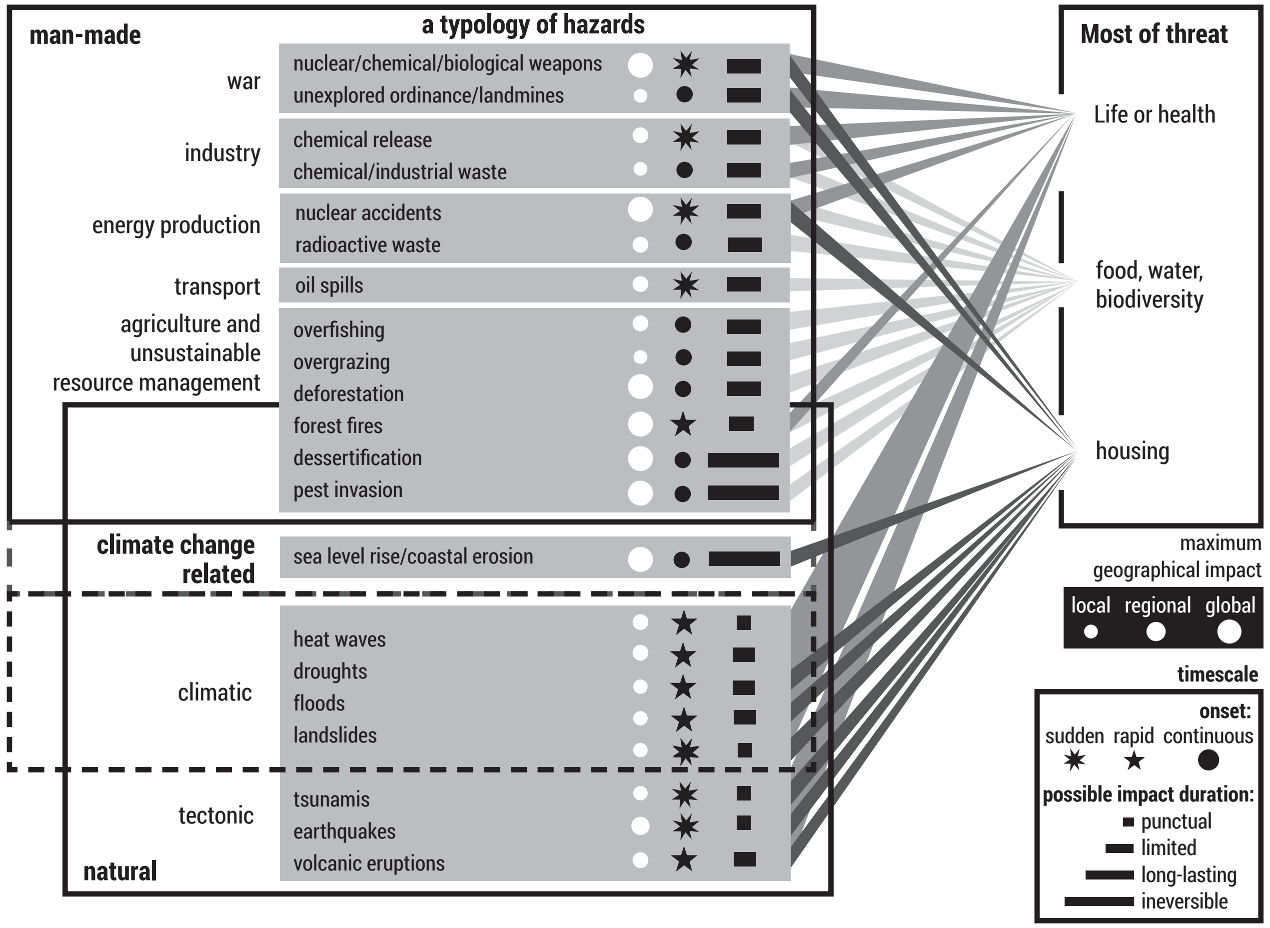


Figure 1. A typology of hazards (UNEP-GRID Arendal)

Design limits for structural measures

Structural measures refer to any physical construction to reduce or avoid negative impacts of hazards, including engineering measures and construction of hazard-resistant and protective structures and infrastructure. Under a DRR initiative based upon present and historical experiences, there is a greater likelihood that design limits for structural measures, such as flood embankments, will not be adequate in the face of climate change. Similar issues could be faced when considering changes in the frequency and severity of storms, drought, and other climate-related phenomena, including sea-level rise. Initiatives focused on climate change adaptation are more likely to design structural measures with consideration for new, predicted impacts.

Table 1. Summary of differences between adaptation and DRR.

Differences		Signs of convenience
DRR	**Climate change adaptation**	
Relevant to all hazard types	Relevant to climate-related hazards	n/a
Origin and culture in humanitarian assistance following a disaster event	Origin and culture in scientific theory	Climate change adaptation specialists now being recruited from engineering, watsan, agriculture, health and DRR sectors
Most concerned with the present – i.e. addressing existing risks	Most concerned with the future – i.e. addressing uncertainty / new risks	DRR increasingly forward-looking Existing climate variability is an entry point for climate change adaptation
Historical perspective	Future perspect	As above
Traditional / indigenous knowledge at community level is a basis for resilience	Traditional / indigenous knowledge at community level may be insufficient for resilience against types and scales of risk yet to be experienced	Examples where integration of scientific knowledge and traditional knowledge for DRR provides learning opportunities
Structural measures designed for safety levels modelled on current and historical evidence	Structural measures designed for safety levels modelled on current and historical evidence and predicted changes	DRR increasingly forward-looking
Traditional focus on vulnerability reduction	Traditional focus on physical exposure	n/a
Community based process stemming from experience	Community-based process stemming from policy agenda	n/a
Practical application at local level	Theoretical application at local level	Climate change adaptation gaining experience through practical local application
Full range of established and developing tools	Limited range of tools under development	None, except increasing recognition that more adaptation tools are needed
Incremental development	New emerging agenda	n/a
Political widespread and recognition often quite weak	Political and widespread recognition increasingly strong	None, except that climate-related disaster events are now more likely to be analyzed and debated with reference to climate change
Funding streams ad hoc and insufficient	Funding streams sizeable and increasing	DRR community engaging in climate change adaptation funding mechanism

Comprehensiveness of measures to reduce vulnerability

The environmental science basis, from which climate change adaptation is emerging, means that adaptation largely focuses on shifting environmental conditions. Without such a strong environmental perspective and background, DRR is more likely to also consider and address social, physical and economic factors. Furthermore, through its inter-disciplinary analysis of conditions across all these categories, the disaster risk management community is more capable of recognising the wider constraints that determine vulnerability. This may account for why the adaptation community tends to place strong emphasis on developing hazard forecasting and early warning systems, whereas DRR, by its nature, extends beyond disaster preparedness measures alone.

The following table highlights the key differences between DRR and climate change adaptation measures and approaches (some inevitable generalisations are made). The table also indicates where there are signs of convergence between the two disciplines.

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Adaptation to climate change in the context of sustainable development and equity

Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.

Estimates of likely future adaptations are an essential ingredient in impact and vulnerability assessments. The extent to which ecosystems, food supplies, and sustainable development are vulnerable or "in danger" depends both on exposure to changes in climate and on the ability of the impacted system to adapt. In addition, adaptation is an important policy response option, along with mitigation. There is a need for the development and assessment of planned adaptation initiatives to help manage the risks of climate change.

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Adaptations vary according to the system in which they occur, who undertakes them, the climatic stimuli that prompts them, and their timing, functions, forms, and effects. In unmanaged natural systems, adaptation is autonomous and reactive; it is the process by which species and ecosystems respond to changed conditions. This chapter focuses on adaptations consciously undertaken by humans, including those in economic sectors, managed ecosystems, resource use systems, settlements, communities, and regions. In human systems, adaptation is undertaken by private decision makers and by public agencies or governments.

Adaptation depends greatly on the adaptive capacity or adaptability of an affected system, region, or community to cope with the impacts and risks of climate change. The adaptive capacity of communities is determined by their socioeconomic characteristics. Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and extremes. In this way, enhancement of adaptive capacity reduces vulnerabilities and promotes sustainable development.

Adaptation to climate change has the potential to substantially reduce many of the adverse impacts of climate change and enhance beneficial impacts—though neither without cost nor without leaving residual damage.

The key features of climate change for vulnerability and adaptation are those related to variability and extremes, not simply changed average conditions. Most sectors and regions and communities are reasonably adaptable to changes in average conditions, particularly if they are gradual. However, these communities are more vulnerable and less adaptable to changes in the frequency and/or magnitude of conditions other than average, especially extremes.

Sectors and regions will tend to adapt autonomously to changes in climate conditions. Human systems have evolved a wide range of strategies to cope with climatic risks; these strategies have potential applications to climate change vulnerabilities. However, losses from climatic variations and extremes are substantial and, in some sectors, increasing. These losses indicate that autonomous adaptation has not been sufficient to offset damages associated with temporal variations in climatic conditions. The ecological, social, and economic costs of relying on reactive, autonomous adaptation to the cumulative effects of climate change are substantial.

Planned anticipatory adaptation has the potential to reduce vulnerability and realize opportunities associated with climate change, regardless of autonomous adaptation. Implementation of adaptation policies, programs, and measures usually will have immediate benefits, as well as future benefits. Adaptation measures are likely to be implemented only if they are consistent with or integrated with decisions or programs that address nonclimatic stresses. The costs of adaptation often are marginal to other management or development costs.

The capacity to adapt varies considerably among regions, countries, and socioeconomic groups and will vary over time. The most vulnerable regions and communities are those that are highly exposed to hazardous climate change effects and have limited adaptive capacity. Countries with limited economic resources, low levels of technology, poor information and skills, poor infrastructure, unstable or weak institutions, and inequitable empowerment and access to resources have little capacity to adapt and are highly vulnerable.

Enhancement of adaptive capacity is a necessary condition for reducing vulnerability, particularly for the most vulnerable regions, nations, and socioeconomic groups. Activities required for the enhancement of adaptive capacity are essentially equivalent to those promoting sustainable development. Climate adaptation and equity goals can be jointly pursued by initiatives that promote the welfare of the poorest members of society—for example, by improving food security, facilitating access to safe water and health care, and providing shelter and access to other resources. Development decisions, activities, and programs play important roles in modifying the adaptive capacity of communities and regions, yet they tend not to take into account risks associated with climate variability and change. Inclusion of climatic risks in the design and implementation of development initiatives is necessary to reduce vulnerability and enhance sustainability.

Current knowledge of adaptation and adaptive capacity is insufficient for reliable prediction of adaptations; it also is insufficient for rigorous evaluation of planned adaptation options, measures, and policies of governments. Climate change vulnerability studies now usually consider adaptation, but they rarely go beyond identifying adaptation options that might be possible; there is little research on the dynamics of adaptation in human systems, the processes of adaptation decision-making, conditions that stimulate or constrain adaptation, and the role of non-climatic factors. There are serious limitations in existing evaluations of adaptation options: Economic benefits and costs are important criteria but are not sufficient to adequately determine the appropriateness of adaptation measures; there also has been little research to date on the roles and responsibilities in adaptation of individuals, communities, corporations, private and public institutions, governments, and international organizations. Given the scope and variety of specific adaptation options across sectors, individuals, communities, and locations, as well as the variety of participants—private and public—involved in most adaptation initiatives, it is probably infeasible to systematically evaluate lists of particular adaptation measures; improving and applying knowledge on the constraints and opportunities for enhancing adaptive capacity is necessary to reduce vulnerabilities associated with climate change.

Six reasons to adapt to climate change now

1. Climate change cannot be totally avoided.
2. Anticipatory and precautionary adaptation is more effective and less costly than forced, last-minute, emergency adaptation or retrofitting.
3. Climate change may be more rapid and more pronounced than current estimates suggest. Unexpected events are possible.
4. Immediate benefits can be gained from better adaptation to climate variability and extreme atmospheric events.
5. Immediate benefits also can be gained by removing maladaptive policies and practices.
6. Climate change brings opportunities as well as threats. Future benefits can result from climate change.

Adaptation here is taken to be a human intervention to address the effects of climate change, and does not include the autonomous response of the ecosystems themselves, for example an increased net primary productivity in many species due to the increased levels of atmospheric concentrations of carbon dioxide (IPCC 2001b).

Adaptation options and their implementation are thus strongly dependent on institutional capacity in the region or country. Specifically, institutional capacity includes both financial and human resources as well as the political will to address the adaptation options for climate change. Such political will can often be related to the national current and future socio-economic development and the current extent of the country's exposure to climate change. The potential for adaptation is more limited for developing countries, which are projected to be the most adversely affected.

Adaptation appears to be easier if the climate changes are modest and/or gradual rather than large and/or abrupt. Many of the adaptation options can not only address climate change impacts but could also provide "win-win" option for other problems, such as wetland degradation (IPCC 2001b). Adaptation options are often limited by our state of scientific knowledge. However, implementing these options, especially the "win-win" options, is often a function of political and governance decisions rather than of the state of scientific knowledge (Finlayson 1999).

Adaptation options should be considered within overall frameworks for sustainable development and should not conflict with the wise use of wetlands. However, given the inertia in some wetland species and functions, the development of adaptation options may not result in rapid responses (Gitay et al 2001). In addition, there is also likely to be institutional inertia. For example, implementation of management plans may be on a ten-year cycle, and that could affect the planning and implementation of adaptation options.

Monitoring of adaptation options should be considered to be an essential feature so that the overall adaptive framework, which should be responsive to the changes being observed either as a result of the adaptation measures or some other factors, can be modified as needed. In this sense the framework for adaptation and mitigation options illustrates the extent of connections that exist between wetlands, their goods and services, and various pressures, including that of climate change.

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Rethinking Resilience:
Social protection in the context of climate change

Climate change, disasters and social protections in Vietnam

The people of Vietnam are already experiencing climate change. Severe weather events such as storms and floods are increasing in intensity. Long-term changes to 'normal' conditions, such as rising sea levels, shifting rainfall seasons, altered crop patterns and long dry periods are gradually undermining livelihoods. Numerous researches in Vietnam have highlighted that people living in poverty are more at risk to the impacts of climate change.

In recent years the importance of social protection, climate change adaptation, and disaster risk reduction have risen in prominence both internationally and in Vietnam. The common goal of these three disciplines is to support resilience against shocks and stresses amongst vulnerable people. Integrating social protection, climate change adaptation and disaster risk reduction in policy, planning and programming presents huge opportunities for multiplying resilience, but it is only recently that development practitioners have begun to conceptually link these approaches.

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For Vietnam, a nation where development is jeopardised by climate change and disasters, and where inequality prevents households most at risk from climate change from accessing resources for adaptation, the question is whether resilience can be fostered at all without an integrated approach.

Adaptation to climate change requires thinking and acting beyond immediate needs to address tomorrow's challenges; but for Vietnam's poorest communities, forward planning and long-term livelihood adaptation is often a luxury that they cannot afford.

The Government of Vietnam and its development partners already have policies and programs with some degree of integration. There is also a growing body of global experience to learn from and to help guide integrated approaches to both policy and programming. This Learning Series offers an outline of the concept of climate responsive social protection and presents the rationale and recommendations for further development of this approach in Vietnam. This rationale is supported by case studies and examples from Vietnam and around the world.

Key points:

Evidence shows that the more projects integrate social protection, disaster risk reduction and climate change adaptation, the more likely they are to improve the livelihoods of poor people.

- Globally, social protection mechanisms are progressively being identified as important modalities for achieving and scaling up disaster risk reduction and climate change adaptation.
- In Vietnam, synergies between climate change adaptation and disaster risk reduction have been increasingly recognised, as the shocks and stresses people face are becoming more and more intertwined. The importance of considering how social protection can support goals related to climate change has been noted.
- There is already a degree of integration in Vietnam's social protection and climate change strategies and policies. Further integrating the approaches will require a long-term vision of resilience, yet immediate measures can be taken to strengthen existing social protection modalities for long term resilience.

Enhancing resilience: The climate reponsive social protection model

Social protection, climate change adaptation and disaster risk reduction all seek to mitigate risks faced by the poor and provide support so that individuals, communities, institutions and ultimately societies can better manage shocks and stresses in both the short and long term.

Providing immediate social protection provides 'space' for poorer households to address the longer term impacts of climate change. At the same time the longer term focus of integrated approaches means that there is less chance that gains from social protection will be eroded by extreme events or slower changes that impact livelihoods. There are also practical arguments of improved cost-effectiveness and efficiency for integrating social protection, climate change adaptation and disaster risk reduction approaches.

The integration of social protection, climate change adaptation and disaster risk reduction is known as adaptive or climate responsive social protection. Climate responsive social protection is an integrated approach for reducing the socio-economic vulnerability of poor people, and enhancing overall resilience amongst at-risk populations. It requires understanding of the interlinked nature of the shocks and stresses that poor people face and the potential synergies to be gained from bringing disciplines together.

Globally, social protection is being recognised as essential in attempts to scale up disaster risk reduction, and a number of countries around the world are acknowledging the importance of integrating the three approaches; some at a national planning level, some through implementing individual programs. International organisations and multilateral and bilateral donors such as the United Nations Food and Agriculture Organization, World Bank, and the UK Department for International Development, have also released policies, strategies or position papers encouraging integration of the concepts.

The rationale for adaptive social protection in Vietnam

In Vietnam, synergies between climate change adaptation and disaster risk reduction have been increasingly recognised, as most disasters in the country have their origins in weather and climate. It is estimated that 70 percent of the Vietnamese population are exposed to risks from such hazards. Many social protection instruments are also already being delivered on a large scale, meaning that systems or mechanisms are already in place and can be modified to take account of climate risks.

Social protection

According to the Social Protection Strategy of Vietnam 2011-2020, social protection aims to target vulnerable groups including the poor and those affected by natural calamities, including climate hazards. Social protection in Vietnam already includes some activities that support disaster risk reduction, such as access to health services, support during disasters and an agricultural insurance pilot.

Climate change adaptation

In Vietnam the main frameworks for medium-term responses to climate change are the National Climate Change Strategy, the National Target Program to Respond to Climate Change and the Action Plan Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sector 2008-2020. These acknowledge the need to mainstream climate change issues into the socioeconomic sectors and local development planning—creating clear links with social protection policies and programs.

Disaster risk reductionI

Vietnam's National Strategy for Disaster Mitigation and Management to 2020 articulates that 'measures for disaster mitigation and management must be compatible with measures for poverty reduction and natural resource protection, so that development can be equitable and sustained'. By introducing a national Community Based Disaster Risk Management Program in 2009, the Government also recognises the importance of awareness raising, risk assessment and planning, capacity development and small-scale mitigation for the most at-risk communities.

Opposite you can see examples of how different social protection modalities could be used to address some of Vietnam's most pressing climate change impacts. These impacts are interacting with non-climate pressures such as environmental degradation, deforestation, industrialisation and modernisation of agriculture, population growth, and urbanisation. For particular vulnerable groups, the impacts of climate change are also linked to underlying inequalities related to factors such as gender, discrimination, illiteracy, language, and governance.

Main climate hazards and stressors in Vietnam

- More intense precipitation and shifting rainfall seasons; unseasonal rain, leading to more irregular floods, landslides and drought
- Extreme events; change in intensity, seasonality and geography: drought, floods, typhoons, wildfires

- Sea level rise leading to inundation, erosion and salt water intrusion
- Increased temperature, increased hot days, higher levels of humidity
- Increase in frequency and length of heatwaves

Climate change impacts

- For climate sensitive crops, livestock and aquaculture: loss, reduced yield and quality, market disruption, heath stress, increased and new animal/plant pests and diseases, invasive species
- Disruption of non-farming livelihoods that depend on agriculture: construction, handicraft, small business, commodity trading, seasonal labour, food processing, garment making, etc.
- Reduced income, loan and debt repayment
- Damage or loss to livelihood and non-livelihood assets
- Reduced mobility, potential displacement or need for resettlement
- Temporary or long term water, food, electricity, telecommunication shortages or disruptions
- Degradation and depletion of natural resources and ecosystems: water, land/soil, biodiversity, forest, and air
- Weakened ecosystem services (pollination, water purification, soil formation, carbon storage, biodiversity)
- Increased mortality and diseases, psycho-social and other health-related stress, decreased labour productivity
- Malnutrition (protein decrease in crops) and food security (food access, utilisation and price stability)
- Disruption to health (including family planning), education and social protection services

Possible climate responsive social protection responses

- Weather index based insurance systems for crops and livestock
- Vocational training that supports livelihood diversification
- Conditional loans for shift to non climate sensitive livelihoods
- Public works that promote resilience, e.g. for water supply and sustainable irrigation, mangrove restoration and tree planning, or landslide prevention measures
- Minimum income assurance for seasonal laborers during flood season
- Vouchers/cash for training in pest and disease recognition and management
- Public works for mosquito-breeding site controls
- Alleviate the impact of managed resettlement, through vouchers for training and education
- Payment for Ecosystem Services, monetary incentives for natural resources management

Opportunities and challenges for climate responsive social protection in Vietnam

In order to determine how Vietnam can better support long term resilience in the context of climate change, CARE in Vietnam has conducted an analysis of key Strengths, Weaknesses, Opportunities and Challenges for integrating social protection, climate change adaptation and disaster risk reduction.

As outlined opposite, some existing government and non-government social protection programs are already supporting climate change adaptation and disaster risk reduction goals. Specific opportunities and challenges for how two key existing social protection schemes could be adapted to better support climate change adaptation and disaster risk reduction goals are provided below.

Opportunity 1: Agricultural insurance

Advantages: Provides pay out when major shocks occur and can encourage farmers to invest in agricultural production as it reduces risk. Developing weather-based indexes will also increase overall knowledge and understanding of the risks of major weather related shocks in Vietnam.

Challenges: Improving access amongst the most vulnerable groups exposed to weather based livelihood shocks is important. The pay-out process also needs to be streamlined to prevent households from taking up negative coping strategies while they are waiting for payment. The program needs to become financially sustainable for insurers and the government.

Opportunity 2: Public works programs through geographically targeted poverty reduction and development programs (Programs 135 and 30A)

Advantages: Public Works Programs can provide guaranteed income during lean work periods as a social protection mechanism. Schemes can then be scaled up following emergencies and scaled back down afterwards to prevent negative coping strategies to support DRR. By linking existing Public Works Programs to DRR and CCA objectives, infrastructure to support community resilience can be built (such as irrigation canals, mangroves or sea walls), and training undertaken to build more resilient livelihoods.

Challenges: Public Works Programs need to support cash transfers, rather than food or in kind transfers, to better promote adaptation goals. This needs to be reliable and set at a level high enough to support adaptation goals. All infrastructure needs to be resilient to climate change, and a broader definition of 'work' is required to incorporate training and other community assets that could support adaptation.

Analysis for integrating social protection, climate change adaptation and disaster risk reduction in Vietnam:

Strengths:

- Social protection, CCA and DRR already have strong government buy in and receive good levels of funding (compared to other countries in the region).
- A number of development partners are already implementing integrated programs.
- National policy for each of the three disciplines already have some level of integrated language and objectives. An array of existing national social protection mechanisms already have elements of CCA and DRR incorporated.
- The people and Government of Vietnam are generally well aware about the need to address climate change which should help improve acceptance for programs that incorporate social protection, CCA and DRR.

Weaknesses:

- There is limited awareness in country about the benefits of integrated social protection, CCA and DRR approaches.

- Local level governments require better understanding of how to integrate CCA and DRR at a local level.
- Important coverage gaps exist for women, and people from ethnic minorities to accessing existing social protection and climate change adaptation schemes and services.
- Training gaps exist in terms of linking people to fast-changing labour needs which could help people adapt away from climate sensitive livelihoods in climate vulnerable areas.

Opportunities:
- Improving access amongst women, people from ethnic minority communities and people living in climate vulnerable areas to existing social protection mechanisms will have immediate returns in terms of improving resilience.
- Cost efficiencies can be achieved by integrating CCA and DRR into existing social protection initiatives.
- Lessons have been learnt from public works schemes, cash programming and agricultural insurance in Vietnam that could be used to develop larger scale and better initiatives.
- Linking differing programmatic approaches could significantly improve resilience, for example, climate resilient livelihood techniques training could be linked to existing microfinance schemes to improve access amongst the poor and to enhance outcomes.

Challenges:
- Reorienting social protection towards improving resilience amongst the poor will require a reprioritisation of social protection funding.
- Coordinating the disparate ministries that oversee the varying aspects of social protection, CCA and DRR at a national and local level will be required.
- The cost of social protection, CCA and DRR are all likely to increase as the impacts of climate change take hold.
- Providing integrated programming will be hard in the northern mountain region where social protection services are already difficult to implement.
- Incorporating the three approaches will require skilled policy and program staff who understand each approach and can identify opportunities for integration.

Recommendations: The way forward

Integrated approaches to social protection, climate change adaptation and disaster risk reduction programming are becoming essential for supporting resilience to climate change. In Vietnam, where there are already strong social protection mechanisms in place that can be adjusted to meet the objectives of climate change adaptation and disaster risk reduction, there are also economic efficiencies to be realised through integration. Integrating the approaches will require a long-term vision of resilience, embedded into national policy, budgets and programs. Yet even at a local level, efforts can be made now to integrate approaches and enhance longer term resilience amongst communities at risk from the impacts of climate change.

National prioritisation to enhance adaptive capacity across the Vietnamese society

The increasing impacts of climate change and the interlinked nature of shocks and stresses to livelihoods amongst the poor will require more formal, forward-looking and systematic forms of protection at the local, regional, and national levels to support climate vulnerable people. This will require an overarching multi-stakeholder commitment to invest more resources in populations that are poor and with low capacity to manage climate hazards and livelihood stresses. It will also require senior level buy in and prioritisation of resilience initiatives.

Institutional strengthening and coordination

Currently there is limited integration and coordination in terms of planning and programming between the ministries in Vietnam responsible for social protection, climate change adaptation and disaster risk reduction. A harmonised approach to planning and programming will require investment at a national and local level so that policy experts and practitioners in government become more versed across all three fields. Effort will be required to facilitate co-operation and joint planning processes and to design harmonised approaches.

Climate informed social protection planning

Social protection policymakers and practitioners need to integrate planning for climate change impacts and plan for a higher frequency and severity of disasters. Social protection mechanisms should consider built-in feedback loops with early warning systems to determine how climate change will impact existing schemes through direct and indirect impacts like food price volatility, food insecurity and migration. Assets developed through social protection schemes like public works need to be 'climate smart' and built for increased resilience.

Social protection becomes a tool of climate adaptation and disaster risk reduction

At a national and local level, policymakers and practitioners working to support climate change adaptation and disaster risk reduction will need to consider how existing or new social protection initiatives can facilitate their goals. This will require an expanded perspective of risk and understanding that current vulnerability reduction can build adaptive capacity to be called upon in times of future risk.

Scalable and flexible programs

Across all three fields, policy makers and practitioners in Vietnam should consider how social protection programs can be designed to allow coverage to be rapidly expanded and retracted during and after disasters and shocks. Achieving scalability requires targeting, registry, and payment systems that can identify, enroll, and make transfers to additional eligible participants as well as funding arrangements that can mobilise adequate resources on short notice.

A livelihood-oriented approach in all three fields will support enhanced resilience

Improving the resilience of vulnerable populations in Vietnam will require a greater focus on livelihoods across social protection, disaster risk reduction and climate adaptation planning and program implementation. The bulk of existing social protection funds are not spent on livelihood supporting mechanisms whereas disaster risk reduction spending has also been heavily geared towards infrastructure spending and awareness raising. Providing livelihood training programs to the poor and climate vulnerable will be particularly important.

A renewed focus on supporting poor and at risk populations with a particular emphasis on women

This will require a detailed mapping of how geographical climate impacts overlay on existing mapping of poverty and inequality patterns. Integrated programming to support resilience will require an understanding of (i) how climate change is likely to affect a geographic area; (ii) which physical, natural, or institutional assets and livelihoods need to be strengthened; and (iii) how programs and processes can be designed to best empower the most vulnerable to participate and gain benefit. Their needs to be a particular focus on how to better include vulnerable women and people from ethnic minorities in program design and implementation as they are presently the most at-risk groups to both poverty and climate change.

Monitoring and measuring impact, with an aim of reducing dependency on social protection through improving resilience

Globally there is limited empirical research related to integrated programming approaches. To ensure that initiatives are working, robust monitoring and evaluation should be built into programming design. Most importantly, integrating programming that seeks to support resiliency will need a clear definition of resiliency with clear objectives built into every initiative. Tracking improvements in resilience capacity is important to ensure that individuals, household and communities are ultimately being supported to a point where they no longer require support.

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Ariel Lucerna 2015

Women adapting to climate change

Climate change has several implications for human security especially given its wide-ranging impacts on critical livelihood sectors and on communities with the least capacity to adapt. While women are important actors in managing natural resources and environmental change, it is also important to focus on the complex questions about how different social groups experience vulnerability to climate change. Both biophysical and social vulnerability have implications to economically poor and socially excluded women and men that shape their livelihood strategies. Climate change is superimposed on existing vulnerabilities. However, given that access and management of environmental resources are socially constructed (Masika et al 1997; UNEP 1995), it is fair to assert that women and men experience vulnerability to environmental change differently, and hence, environmental degradation will have different impacts on women and men.

Adapting to climate change will require a broad range of efforts, incentives, resources, commitment and active interventions throughout most parts of society. Women should be at the centre of adaptation programmes because they are a particularly vulnerable group

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because of limited access, control and ownership over resources, unequal participation in decision and policy making, lower incomes and levels of formal education, and extraordinarily high workloads. On the other hand, women need to be at the heart of adaptation efforts because of the significant roles they play in agriculture, food security, household livelihoods and labour productivity. Within these critical roles, women have valuable knowledge, skills and agency in managing natural resources and are often at the front-line of adaptation to climate change in the context of high rates of men's out-migration. Thus, women provide a central opportunity for promoting sustainable mountain development.

Furthermore, adaptation efforts will also have to address the full range of challenges and opportunities related to gender inequities, including cultural, economic, social, political, health and environmental issues. The latter factors are very relevant to resilience and adaptive capacity (UNEP 2009; 2010). Among the critical factors that can assist in gender sensitive adaptation are increased access and ownership of land, micro-credit directed to women, water, livestock, storage facilities, agricultural inputs, markets, education and green technology. These must all be culturally appropriate, socially acceptable, responsive and practical for women's needs (Devendra and Chantalakhana 2002; Hussain 2007; UNEP 2009; 2010; Shackleton et al. 2010; Sijbesma et al. 2009). It is critically important to spend the time necessary to factor into development research and action the approaches that focus on women's demands, concerns, experiences, priorities and needs. Women who take part in action-oriented research often have a clear sense of what they need to adapt better to changes in their environments, climate and livelihoods (Mitchell et al. 2007). Moreover, innovative strategies need to be grounded in mountain and culturally specific realities, needs and aspirations (Khadka et al., forthcoming).

According to a recent report on gender and adaptation to climate change, women "have been experiencing changes to the weather that have affected their lives, and are adapting their practices in order to secure their livelihoods. They might not be aware of all the possible adaptation strategies, of all the ways to overcome constraints to the ones they are using, but they certainly know their present situation best and have an urgent list of priorities to secure a livelihood in the face of the new challenges" (Mitchell et al. 2007:14). For instance, these needs include initiatives, trainings and exposure exchange visits on appropriate and culturally specific crop diversification, adaptive agricultural practices, post-harvesting approaches, innovations in animal husbandry and alternative livelihood practices). To reduce the vulnerability of women, and increase the capacity of society as a whole to adapt to a changing climate, women will have to be central in the coming decades if sustainable adaptation strategies are to be implemented.

Gender-sensitive responses will require more than the collection of disaggregated data illustrating differential impacts on women and men (if available). They will require an in-depth understanding and rigorous analysis of existing inequalities and gender power relations between differently positioned women and men, and of the ways in which climate change exacerbates these inequalities and relations (Brody et al. 2008; Verma 2001). For these reasons, it is important that women actively and equitably participate in policy and decision-making processes within their household, community and national and international institutions (both customary and statutory), so that their knowledge, contributions, agency and work are valued and their capacities, confidence and voice are boosted and enhanced. One important lesson in advancing gender issues and analysis is the importance and critical difference between gender awareness, gender promotion and gender analysis. Not all the same actors, approaches and methods may be involved in creating greater awareness of the importance of gender and climate change adaptation issues, actively promoting it, or scientifically and systematically analysing the differentiated impacts, resilience and adaptation strategies of women and men (Verma 2001). Gender awareness and advancement of gender issues and equity is needed from actors from all different disciplines, institutions, organisations and contexts.

"Women play very crucial role in climate change adaptation and mitigation, even though their contribution is overlooked or less acknowledged. Many of their works related to natural resources management are contributing to mitigation actions. Whereas, women perform many activities for the well being of their family members, which simultaneously can be regarded as well designed adaptation practices. Women adopt diverse and intense household resource-use strategies to cope with food deficit situations, especially during lean seasons and natural disasters. They intensify their efforts in homestead production and seek non-farm production options for the well-being of the family. Moreover, women perform some infrastructural development to conserve the soil and water and also to avoid floods by building embankments which presumably make a large contribution to the efforts required to confront climate risks." (Baten and Khan, 8:2010)

However, gender analysis requires rigorous, in-depth technical skills of analysis, as in any other field. As well, efforts must be made to ensure rigour, depth and further strengthening of technical capacity in this emerging field. In-depth gender analysis cannot be a mere 'add-on', a box to check off, or a rapid method of "doing gender"—not if it is to accurately reflect women's and men's complex gender realities in the face of climate change (ibid.). At the same time, gender awareness and promotion is critically valuable for political and environmental action, for creating gender-positive action that makes a difference, for challenging gender-biased and blind discourses and inequities, and for changing research and development agendas in gender-positive directions.

It is also worth remembering that women are not a homogenous category, that they are differentiated by age, class, caste, marital status, life-cycle positioning, ethnicity, profession, etc., in ways that affect, shape and magnify or reduce their vulnerabilities, risks and coping strategies. For instance, women are more acutely vulnerable to climate change because of limited access to resources and decisionmaking power if they are of lower caste, poorer economic class, heads of households (both de jure and de facto), younger in early stages of marriage, and young girls in times of disasters and economic crisis, etc. Women of lower castes are sometimes disadvantaged in terms of status, have limited access, control and ownership of resources, and are excluded from decision-making at community level and disaster preparedness planning (Leduc and Shrestha 2008). Women and young girls forced to migrate are also exposed to multiple vulnerabilities, including the risk of rape and trafficking (discussed earlier). Women and men tend to perceive different risks as important and attribute different meanings to material realities and environmental changes (Moore 1993) and the experiences they face due to socially constructed roles, responsibilities and identities.

Women are often the managers of natural resources with knowledge and skills that are critical for sustaining the environment. They are at the frontline of coping and adapting to climate and other critical drivers of change. Although they are often excluded and under-represented in decisionmaking institutions and policy processes regarding climate change, women are active agents who have developed locally adapted, appropriate and sustainable coping strategies and responses within the scope of limited access to resources and disadvantageous gender power relations.

Given that both vulnerability and climate change are socially constructed, contested and gendered concepts (Denton 2002) and are further shaped by discourses that often "suspend" and ignore gender issues, it is important to "dig down and pull up the deep roots of the discourses that frame gender and climate politics" (MacGregor 2010:236). In this regard, it is also critical to highlight the ways in which certain concepts of knowledge, culture and power relations will shape institutional discourses, ideologies and practices of development and the everyday practices of women and men to manage their environments and natural resources (German et al. 2010).

Imagine what is possible if climate change policies and initiatives actively address dominant and often gender blind discourses and the power relations that shape much of gender inequality throughout out the world. Envision the possibilities if we actively work against the gender "evaporation" that more often than not tends to take place when we attempt to gender "mainstream" or integrate gender issues in the face of limited resources, political will, commitment and systematic approaches (Verma, forthcoming). Imagine what is possible if women are given due recognition and are included in development and policy processes as strategically important development actors in their own right.

There is little doubt that women as agents and adaptors to climate change are key to sustainable adaptation in mountain regions. To reduce the vulnerability of women and increase the capacity of society as a whole to adapt to a changing climate, women must be central in sustainable adaptation strategies to be implemented in the coming decades, and if valuable context-specific adaptation strategies are to be given the chance they deserve to provide hope for the future.

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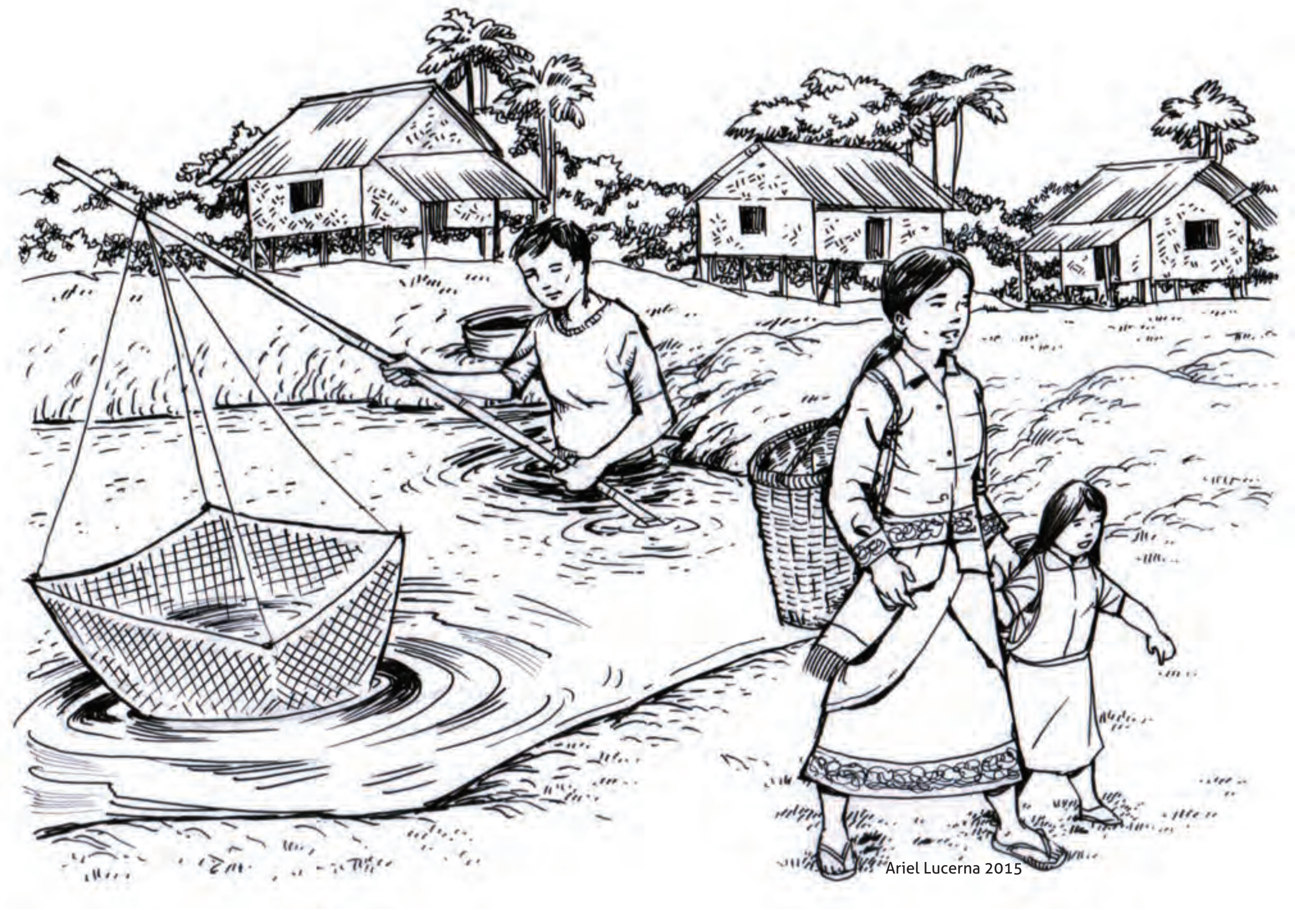

Gender differentiated impacts of climate change

The differential effects of climate shocks on men's and women's well-being and assets

Disparities exist between men's and women's access to and control over key assets. Rural women in developing countries generally have fewer assets and rights than do men; they are more vulnerable to losing their assets and rights due to separation, divorce, or widowhood; and they have less access to capital, extension services, inputs, and other resources related to agricultural production. Nevertheless, women's asset holdings often have positive effects on important development outcomes, including household food security and human capital formation. Consequently, helping women gain greater access to and control over key assets can increase resilience of households and communities to climate change.

A review of the literature suggests that considerable differences exist in the ways that climate change and climate shocks affect men and women in the areas of agricultural production, food

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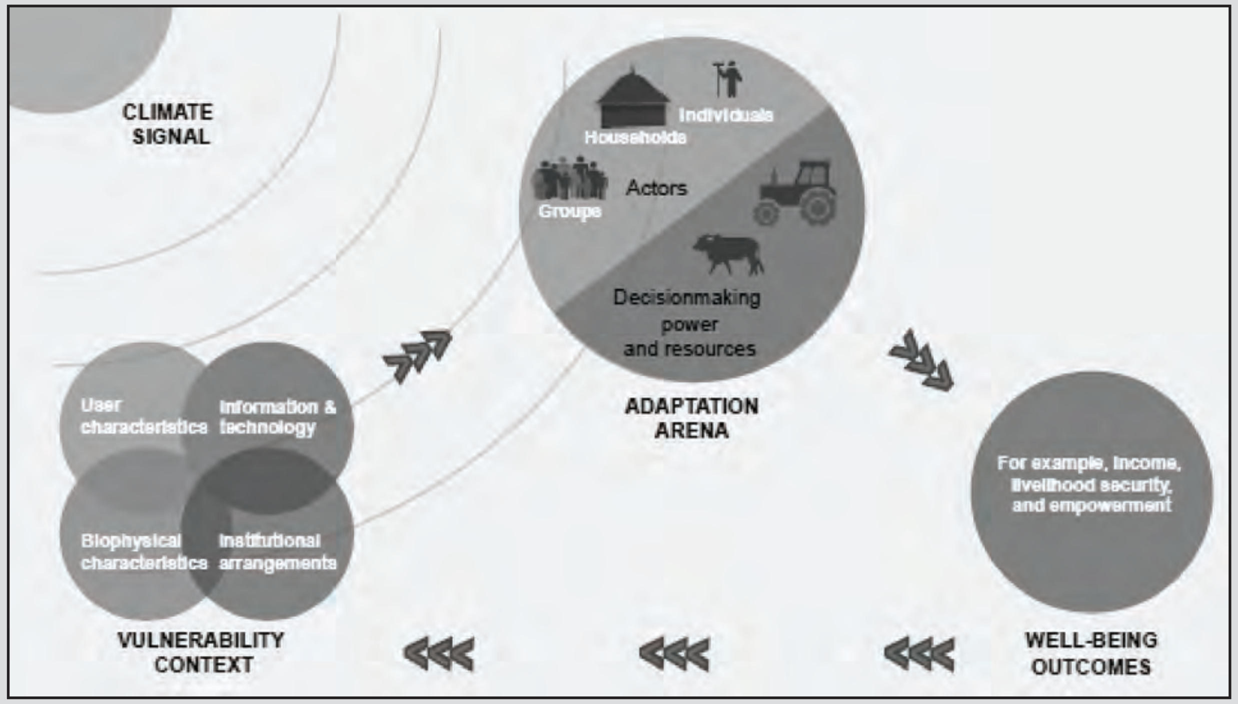
security, human health, natural resources, conflict and migration, and natural disasters. The gender-differentiated impacts of climate change are neither straightforward nor predictable. They vary by context and are mediated by a host of sociocultural, economic, ecological, and political factors.

In terms of agricultural production, increasing climate variability tends to lower agricultural production and has different impacts on women's and men's well-being and assets, including land, livestock, financial, and social capital. The extent to which crop losses result in asset and livelihood losses for both women and men depends on the context, as well as on men's and women's household roles and asset holdings. Increasing climate variability causes both women and men to invest more time and labor in agricultural production, but women's workloads tend to be heavier because of their additional domestic commitments. Women, however, have less access to agricultural technologies and inputs, which puts them at a disadvantage in adapting to climate change impacts.

The literature suggests that climate change may also affect men's, women's, and children's food security differently, but women and children are often more affected in terms of their

A FRAMEWORK FOR GENDERED ADAPTATION TO CLIMATE CHANGE

A framework was developed drawing on the Sustainable Livelihoods Framework of the UK Department for International Development; the Institutional Analysis and Development Framework, pioneered by Elinor and Vincent Ostrom (both now deceased); the Gender and Assets Framework of the International Food Policy Research Institute (IFPRI); and the climate change framework of the Third Assessment Report of the Intergovernmental Panel on Climate Change (see Figure 1 for how this framework is conceptualized). This consolidated framework illustrates the pathways through which climate change affects well-being at the individual, household, and community levels. It can be used to promote an understanding of the differential impacts of climate change on men and women and, similarly, an understanding of men's and women's differential responses. In the context of vulnerability to climate change and the process of adaptation, this framework emphasizes the value of information, livelihood resilience, institutions, and asset accumulation.



Source: Authors.

Figure 1. An integrated framework on gender and climate change.

health and development. In times of stress, as in the case of climate shocks, women often reduce their own food intake or sell assets, such as jewelry or livestock, to ensure their household's food security, while men seek additional income-earning opportunities. The differential impacts on women's and men's physical health are not clear in the literature, apart from one study suggesting that the indirect effects of malnutrition put women and children at higher risk of contracting diseases in postdisaster situations. There is limited evidence of the differential impacts of climate-related events on men's and women's physical, psychological, and emotional health, but women often report more psychological and emotional distress following climate shocks.

Climate variability increases the scarcity of basic household resources, such as water, fuel, and fodder, and in turn increases women's workloads in terms of the time and the energy required to source, collect, and carry these resources to meet household needs. The additional time devoted to this single activity is also likely to have negative impacts on the longer term health and well-being of women and girls, and can erode their economic opportunities to participate in education, training, and income-earning activities. Natural resource scarcity precipitated by climate change may also increase conflicts over available resources. Evidence is still patchy, but better methods and approaches to investigating the impact of climate change on human security and conflict are being developed. It is likely that climate-induced migration of men in search of work has consequences for both men and women, albeit in different ways.

The immediate impact of climate-related disasters such as hurricanes and floods on individuals is determined by their ability to evacuate to safety in time. Sociocultural factors, such as social norms that prevent women from moving freely in the community or learning to swim, and access to information, such as early warning systems, determine who survives natural disasters. Women tend to be more vulnerable and have less access to resources, assistance, and support than do men in the aftermath of extreme climate events.

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Ariel Lucerna 2015

Gender and climate change

Introduction

Women and men differ, that much is obvious. But many of the ways in which society treats men and women differently—such as division of labour, access to credit, decision-making power, ownership of land, opportunities for education and many others—are social constructs rather than biological facts. Those differences can change, and can change swiftly. The development community has embraced these ideas and explored ways to transform perceptions of gender roles, but more upstream research has been slow to move beyond seeing gender as the biological differences between men and women.

For that reason the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) has made the need to understand and transform gender dynamics in relation to climate change one of its most important priorities. Given that women make up 40% of the agricultural labour force in low-income countries, and are largely responsible for household food security, transforming gender perceptions and norms is indeed critical for smallholder adaptation to climate change.

This article was drawn from the original article entitled *Gender and climate change: Enabling people to reach their full potential in adapting agriculture to climate change* distributed by CCAFS Coordinating Unit. Refer to the source box towards the end of this article for a complete reference to the original article.

CCAFS helps identify key research question

CCAFS is working very closely with non-governmental organisations such as CARE International and development agencies such as the International Fund for Agricultural Development (IFAD) in order to ensure that the results of CCAFS gender-sensitive research feed through into development approaches that promote gender transformation.

Understanding gender roles

As input to this planning process, CCAFS convened a group of leading experts to identify key research questions related to gender and climate change.

- How might women and men differ in the effects of long-run climate change, how might their adaptation options and strategies differ (as individuals, in households and in communities) and how do their capacities to adapt differ?
- What causes and characterises gender differences in vulnerability to weather-related risks, and how might properly targeted information help women and men to manage such risks?
- What institutional arrangements would offer appropriate gender-specific incentives to reduce carbon footprint, and can these institutions be made more equitable with respect to gender?
- How do the options for dealing with climate change differ for men and women and at different spatial and temporal scales, and how do gender relations and control over resources affect decisions over which adaptation and mitigation portfolios are adopted?
- What can be done to address the different needs of women and men facing the challenges of climate change?

The first four sets of questions will help to fill evidence gaps in current and planned CCAFS research, while the fifth will encourage researchers to undertake gender-differentiated assessment of proposed solutions.

"Many of the ways in which society treats men and women differently... are social constructs rather than biological facts."

From theory to practice

The expert group identified a need for new gender-climate change focused research methods and capacity building in CCAFS target regions. A collaborative effort with FAO gender experts led to the development of training guidelines on Gender and Climate Change Research in Agriculture and Food Security for Rural Development. The CCAFS-FAO guide, also available in French and Spanish, contains practical advice for field researchers to help them document the differences between men and women and also explains why gender-sensitive approaches are so important for initiatives aimed at enhancing adaptive capacity to climate change. Equipped with the guide and training in gender-sensitive participatory research methods, CCAFS collaborators (and others) are going into the field better prepared to thoughtfully and equitably engage both women and men. These approaches allow researchers and community members to reach a more nuanced understanding of the various adaptation and mitigation options that are best suited to the needs of different kinds of people facing a wide range of environmental and other changes.

Paying attention to gender, as the training guide suggests, can reveal surprising ways in which a minor change can help women. For example, during a CCAFS study in Kaffrine, Senegal, it emerged that while men like to get weather forecasts from rural radio stations, women prefer to receive the information through more personal contact. Forecasts on the radio continue, but in addition the local agricultural extension agent now brings information from meteorologists directly to local women farmers. Results show that farmers who took these forecasts into account—whether from the radio or from a personal contact—were better able to plan for the season ahead and increase their productivity.

Research has shown that women often grow 20–30% less food than men for their efforts, the cumulative impact of all the ways in which societies treat women differently. If this gender gap were eliminated, the Food and Agriculture Organization of the UN (FAO) estimates that total agricultural output in developing countries would increase by 2.5–4%, which could reduce the number of hungry people by 12–17%.

The need for a rapid and wholesale transformation of gender relationships is urgent. Biology is not destiny. That much ought to be obvious too.

To find out more about CCAFS:

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic partnership of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT). CCAFS brings together the world's best researchers in agricultural science, development research, climate science and earth system science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security. www.ccafs.cgiar.org

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Small-scale farmer innovation systems

After working for many years to preserve policy space for SSF innovation in multilateral intellectual property (IP) instruments, QUNO made the strategic decision to take step back from IP. The work is now being approached by seeking a better understanding of SSF innovation and what form the components of an enabling environment might take, and asking how this relates to more formal systems that purport to provide incentives for innovation, including the role of intellectual property rights (IPR). QUNO convened its first consultation to share and compare experience from around the world on SSF innovation, generate ideas, stimulate and reinvigorate alliances among groups.

The participants were presented with a preliminary literature review and asked to add their knowledge and experience to supplement anything that was missing. In addition, QUNO presented the working hypotheses that underpin our work and approach for comment and refinement.

This report summarizes the five main topic areas addressed during the two days of rich discussion, following a sequence that broadly reflects the flow of conversation:

This article was repackaged from previously published materials entitled *Small-Scale Farmer Innovation systems: Report on the First Expert Consultation* by Quaker United Nations Office. Refer to the source box towards the end of this article for a complete reference to the original article.

In May 2015, QUNO (Quaker United Nations Office) convened a small expert consultation in Geneva to discuss small-scale farmer innovation systems.

The event brought together 19 participants from 12 countries, including some people in Prolinnova network. This attached report brings QUNO's synthesis of what was discussed over the two days.

1. SSF innovation in practice: what does it look like, who is involved, and the dual nature of private gain and public goods that may be generated through SSF innovation.
2. Drivers of SSF innovation, how these drivers may differ from those of 'formal' sector agricultural innovation systems and what that means for creating an enabling environment for the former and partnerships between the two;
3. Building bridges and facilitating equal relationships among various actors engaged in agricultural innovation;
4. How conventional policies put in place to foster innovation in agriculture may impede SSF innovation, and what alternative policies may contribute to a more supportive, enabling environment for SSF; and SSFs' innovative capacity and recognize its value to the international community, including any critical points of leverage.

Additional crosscutting themes that came up throughout the two days included:

- The importance of farmers' informed participation in policy processes;
- The need to communicate strategically with bodies engaged in overlapping areas of interest, given the multi-faceted and often intangible value of SSF innovation;
- The tension between the push to scale-up innovation to achieve broader impact or spillover effects from investment and the highly-localized nature of SSF innovation;
- The general orientation of institutions and organizations engaged in agricultural development towards innovation that is quantifiable;
- The 'projectization' of research and development investment;
- The increased involvement of the private sector in agricultural research and the diminishment of the public sector both in terms of resources and its embrace of market-based solutions; and
- The need to reposition the public sector to better reflect the public interest including food security, poverty eradication and the support of SSFs as innovators providing direct and indirect benefits locally and globally.

The final section of this report documents research gaps identified throughout the consultation and QUNO's next steps.

1. SSF innovation in practice

Who innovates?

The meeting recognized that SSFs live close to the land and have an important role in understanding ecosystem complexity. Women play particularly important roles in on-farm experimentation, conservation and with nutrition. Indigenous and local communities' dynamic knowledge systems are particularly valuable for facilitating innovation. While not all farmers may be innovators within their communities, many have the capacity and potential to become innovators with confidence building nurturance and space for their voices to be heard. It was noted that many SSFs will rapidly integrate innovation from colleagues and fellow farmers into their own agricultural practices.

'Formal' and 'informal' innovation systems

Participants debated the value of viewing SSF innovation systems as distinct from more 'formal' agricultural innovation systems.2 A consensus was reached that there is less a strict dichotomy than a continuum between 'informal' and 'formal' innovation systems, but that there is still value in focusing attention on the less formalized end of the spectrum, as alternative conceptions of innovation need to be represented in policy discussions on innovation in agriculture. Importantly, focusing on SSF innovation does not exclude collaborative research efforts. Participants emphasized the synergistic relationship between 'formal' and 'informal' innovation systems and the importance of institutionalizing SSF innovation within the public sector in particular. 'Collective innovation' between public sector scientists and SSF innovators involves the cross-fertilization of knowledge, synthesis and validation of research results.

Participants agreed that, while acknowledging the dangers of oversimplification, more 'formalized' institutions and organizations engaged in agricultural innovation, including both public sector and private industry research and development efforts, tend to be more market-orientated and commodity-based. Outputs of innovation processes are generally protected using IPR, with their value framed in terms of economic benefits: either to individual farmers (in the case of the public sector), or to the corporation (in the case of private industry). This perspective discounts outputs that are more intangible and difficult to quantify but benefit communities and societies at large.

How innovation is defined

SSFs continually innovate by experimenting on-farm and adapting to changing conditions. The meeting discussed the many different forms this can take. It may involve technical and/or institutional change and extends well beyond the enhancement of genetic diversity, encompassing farm income diversification strategies, new management practices, as well as new ways of organizing and sharing information.

One example of institutional innovation was cited where farmers actively involved in on-farm conservation are pushing to become a legal entity so that they may be eligible to share in the benefits arising from the use of plant genetic resources housed in the International Treaty's Multilateral System. An example of technical innovation was cited where women farmers, in developing novel food processing and preservation techniques, are contributing to local food security and nutrition.

Innovation as a process happens through networks. It is informal, social and cumulative in nature as individuals and communities build off one another and strategically adapt new tools and techniques to suit their particular circumstances.

The group agreed that the definition of innovation is significantly broader than what is conventionally considered, i.e. the development of particular technologies that can be scaled-up and widely disseminated to farmers. Outcomes are often not as easy to quantify or commoditize as they are with newly developed varieties.

Many participants emphasized that it is important to consider the power dynamics at play in defining what is considered innovation, and upon what criteria decisions are made to support certain kinds of innovation. Innovation where it is easier to capture economic benefit, for example where it contributes to market growth, is more often supported than innovation where economic value is harder to assign, such as in the case of a mixture of landraces beneficial over generations, or a variety or species with no known monetary value. It is the latter where the public sector becomes critical, because it is in the public interest to support this kind of innovation and there is unlikely to be a market-based incentive for private investment. SSF innovation also often builds upon and reinforces cultural and spiritual values associated with the land, which are also not reflected in market values.

Public goods value of innovation

Farmers themselves are not only private actors supporting local food security and rural livelihoods but also key players in the provision of public goods in the areas of health, nutrition and agroecosystem resilience.

A few participants highlighted that SSFs' innovations do not necessarily, or in all cases, lead to improvements in local food security conditions or ensure environmentally sustainable outcomes. An example was cited of farmers combining four to five types of pesticides in a novel approach to increase the range of crops' resistances that negatively affected soil and water quality in the area. The criteria that SSFs use for deciding what is considered good innovation may be expanded through interaction with other knowledge systems. Supporting SSF innovation should be understood as one important avenue for pursuing positive social, economic and ecological outcomes, but insufficient by itself.

Additional measures need to be in place to incentivize farmers' contributions to providing public goods and actions taken that serve the public interest.

Scalability of SSF innovation

Participants debated whether and how SSF innovation can be scaled-up and out to other farming communities. It was recognized that 'technology packages', or combinations of specific outputs from either SSF or more formalized innovation processes, generally have a short half-life and may not be appropriate outside of the locality in which they were developed. On the other hand, new and better ways of doing things developed in one area may in some cases benefit others in similar climates or socio-political contexts.

It is ambiguous whether policies geared towards scaling-up or exporting SSF innovations benefit both the SSF innovators themselves and SSFs in other areas. Site and region specificities were mentioned as a challenge in themselves in terms of scaling up local innovations. While a lack of consensus was reached on this point, it was highlighted that principles rather than practices can be exported widely without the risk of disseminating innovation that does not suit the specific needs and contexts of other communities. Borrowing principles from the fields of agroecology and natural resource management most relevant to SSF innovation will be useful to further inform this discussion.

Context: the shrinking and focus-shifting public sector

The shrinking public sector was brought up repeatedly throughout the consultation, and was flagged as a core issue at the outset. The public sector was identified as part of a strategy for increasing recognition of farmer knowledge, expertise and capacity and further fostering that capacity. However, the public sector is itself under pressure to take on a role more traditionally associated with that of the private sector—generating revenue for operating funds, reducing risk for private sector investment, promoting commercialization and market-driven investment in research and extension services. The shrinking public sector and influx of public-private partnerships and 'philanthro-capitalists' has led to a shift in focus away from the public interest and those most in need to market-based solutions for those with the ability to pay.

Correlated with this shrinkage is the 'projectization' of public investment in agricultural development, wherein short-term funding is allocated to specific projects and small islands of success are achieved, rather than institutionalized and sustained support for farmer-led research. This has also had a chilling effect on more basic, upstream agricultural research. Donor-driven projects, whether public sector or philanthropic, tend to have a short timeline and need to demonstrate quantifiable impacts very quickly. Donor recipients must prioritize the development-specific outputs that can be scaled-up and out ('spillover effects') rather than processes for building capacity to innovate. Participants discussed how this is generally not conducive to supporting SSF innovation, which is understood to include conservation and development of agrobiodiversity and local knowledge systems over the long-term, and requires social capital and capacities that take time to foster.

A vibrant public sector (to match the now robust private sector engagement and investment) has an important role to play in supporting SSF innovation.

2. Drivers and motivations to innovate

Participants discussed the reasons why SSFs innovate, highlighting that drivers are context-specific and can affect individuals and communities differently. Farmers are both proactive and reactive, responding to both negative pressures and positive opportunities. A few participants highlighted farmers' curiosity and propensity for experimentation, something frequently underestimated due to the assumption that farmers only make changes in response to external pressures. SSFs generally innovate in order to address needs at the individual and community level, rather than for the explicit purpose of scaling-up innovations to higher levels.

Participants identified five main motivations for farmers to innovate: (1) environmental pressures and climate change, (2) the need for livelihood improvement and food security at the household and community levels, (3) new market opportunities, (4) cultural and spiritual values ascribed to sustainable use and management of the land, and (5) personal attributes such as pride and curiosity, social recognition and the desire to avoid relationships of dependency. The first two motivations are push factors (for survival), the third is a pull factor (for opportunity) and the last two are neither, which raises interesting questions regarding how on-farm innovation may be nurtured as opposed to incentivized.

There may be significant overlap between what drives farmers, public sector researchers and scientists and private industry stakeholders to innovate. Nevertheless, consensus was reached that SSFs have a uniquely broad set of motivations for pursuing new ways of doing things on-farm.

Private industry actors are driven to innovate by access to new markets, consumer demand, new technologies and IPR (pull factors). Public sector actors may have broader social and ecological goals driving innovation such as poverty alleviation and ecosystem resilience (push factors), although public investment in agricultural innovation has been in decline over the past several decades. There is a risk that the interests of industry stakeholders dominate and 'capture' development goals within the context of public-private partnerships. 'Philanthrocapitalists' may be driven by altruistic motives but also tend to be market and output orientated, focused on achieving quantifiable impact.

The drivers of innovation naturally influence the outcomes of innovation processes. Participants underscored how differences in motivations between those of farmers and 'formal' sector actors (including actors from the public sector, private industry and public-private partnerships) present challenges for bridging innovation systems.

3. Building bridges and fostering genuine Collaboration

Participants discussed how bridges can be built between farmers and public and private institutions and organizations. The conversation centered on how formal and informal innovation systems may be bridged while recognizing a power imbalance between them.

What hinders bridge building?

The biggest hindrance is that innovation discourse within both international institutions and national innovation strategies does not adequately recognize the innovative capacity of SSFs. The predominant logic is that agricultural innovation happens off-farm and in the hands of 'professional' breeders and scientists. SSFs' capacities to innovate are often underestimated. The focus of innovation strategies remains on raising farmers' capacities to receive and implement new technologies, rather than fostering the capacity to innovate on their own behalf to overcome specific local challenges. Collaborative efforts between innovation systems have typically involved bringing farmers' innovations into a more formalized innovation system for the ends of scaling up commercially viable 'successes'.

At the same time, 'professional' breeders and scientists often lack the capacity to work directly with farmers and co-create knowledge in equal partnership. It was highlighted during the consultation that those who are considered experts often have a harder time making paradigm shifts than farmers or others who work directly with farmers. The consequence is that even when farmers are included in innovation platforms convened by 'formalized' institutions and organizations, their knowledge and innovative capacity is undervalued and unequal power dynamics are perpetuated. Innovation policy does not generally recognize SSF innovation, and by extension, does not take the broader range of drivers and motivations influencing SSF innovation into account.

The top down approach also leads to a lack of information on the SSF side, which can hamper meaningful SSF participation. The meeting discussed how SSFs frequently lack access to information about the various initiatives to improve agricultural production in their country. Information on seed and fertilizer may be available through projects funded by donors, but SSFs are not offered a range of choices or even information about the possible negative effects of the choice being presented.

Another challenge is that the outcomes of on-farm experimentation are often more difficult to quantify and assign economic value to, which is a cornerstone of conventional agricultural development efforts. Some of the benefits of SSF innovation are intangible, such as contributions to cultural heritage, while others may not have a commercial value today but are important for the future, such as genetic diversity. SSF innovations often do not meet the conditions for IP protection: SSF innovation is often a collective rather than an individual effort and assigning individual property rights may be incompatible with local customary laws. Different worldviews concerning the value of land and natural resources must be bridged.

As an illustrative example, in the case of plant variety protection, a variety must be distinct, uniform and stable to qualify for protection. Even if a farmer's variety could meet the criteria, the value would be assigned to the particular variety rather than the full breadth of diversity from which it was developed. The value in farmers' varieties, which are often mixtures, is their diversity and their adaptability over time rather than their uniformity and stability—qualities less easily quantified and commercialized. It was noted that some IP tools such as collective marks or geographical indications might be better suited to serve collective interests of SSFs.

Fostering genuine collaboration and 'co-production' of knowledge

The consensus was that scientists and researchers need to actively support farmer-led research and experimentation, strengthening informal systems rather than formalizing them. Farmers and researchers need to be kept on an equal footing when integrating knowledge systems.

New institutional frameworks that facilitate power sharing and trust building are essential. Capacity must be built among scientists and researchers from the 'formal' sector to work within a more collaborative research framework towards the genuine co-production of knowledge. They must be open to new epistemologies outside of their training and be prepared for genuine interaction and exchange.

Governance of, or control over, collaborations or innovation platforms must be at least equally in the hands of SSFs. The meeting agreed that prerequisites for this include SSFs' capacity for self-organization, capacity to resolve tensions within both partnerships and their own communities, confidence, and awareness of the interests and relative positions of other actors. Mutual respect, trust, communication and recognition of others' perspectives, worldviews and values were identified as tenets of equal partnerships. In particular, a lack of trust on the part of farmer-innovators towards other individuals and organizations hinders collaboration. To this end, the imperative that academic researchers receive innovators' consent to publish information on novel products and practices was emphasized.

Intermediaries are needed to facilitate bridge building and the co-production of knowledge. Such a measure can help to ensure that collaborations are equitable and translate knowledge and ideas among parties. It was suggested by one participant that 50% of attention and resources in research and development initiatives needs to be dedicated to communication and translation of research processes and results, both literally (different languages) and figuratively (adapted to different contexts). The remaining 50% should be dedicated to the research and development effort itself. This emphasis on communication was echoed throughout the consultation.

A revitalization of public sector research is also needed to bridge innovation systems. Public sector researchers working in participatory plant breeding already recognize the value of local knowledge systems. It was highlighted by several participants that public sector agricultural research undertaken by international agricultural research centres (CGIAR centres) and national agricultural research systems (NARS), if substantially reassessed and restructured, could be complementary to SSF innovation.

Participants emphasized the need for SSFs to be engaged and have their voices heard within local, national, international and institutional policy making processes. The meeting noted that donor-led interventions (e.g. the G8 Alliance for Food Security and Nutrition and the Alliance for a Green Revolution in Africa (AGRA)) encouraging the adoption of hybrid-seed, fertilizers, credit provision and the commercialization of agricultural production in general are happening without the consultation of the supposed beneficiaries: small-scale farmers themselves.

4. Agricultural innovation policy and SSF Innovation

Where innovation policy meets SSF innovation

The question of scale arose in relation to how policies affect SSF innovation. Some participants suggested that SSFs' experimentation and innovation, which meets immediate local needs and is not scaled-up and out to other communities, does not often come into direct contact with national and international level policies pertaining to IP, market access or other incentives for encouraging investment in agricultural research and development. That is, farmers' activities at the smallest scale often continue both unimpeded and unsupported by existing policies for fostering innovation in agriculture. On the other hand, farmers' innovations that get scaled-up are more likely to face challenges relating to the uniformity demanded by international markets and transaction costs associated with meeting industry standards.

However, it was recognized that any national policies that put negative pressure on informal seed systems, agrobiodiversity at all levels, diverse farm management practices or local knowledge systems may impede SSF innovation, irrespective of scale. The unintended consequences and trade-offs arising from policies focused on encouraging agricultural innovation (as conventionally defined) have not been the focus of policy debates. The meeting agreed that there is a need for greater understanding and awareness of these consequences and trade-offs.

National policies formulated in accordance with multilateral treaties or other institutional obligations are rarely crafted in consultation with farming communities, and these may in some cases negatively affect farmers' freedom and capacity to innovate both now and in the future. There are multiple stakeholders involved, often with contrasting interests. Participants also emphasized the importance of grassroots movements in protecting the interests of farmers, and of public research institutions in supporting farmers' movements. SSFs must have the space to participate in policy making through consultation, as well as the capacity to mobilize through social movements and political action to create new space. Farmers' mobilization and active participation in policy discussions at all levels is essential.

Policies that may impede SSF innovation

It was agreed that farmers' lack of land tenure and/or other territorial rights (or lack of clarity on these rights) can greatly affect their ability to respond to both challenges and opportunities.

National seed policies and other regulations that require standardization and certification of seed varieties or other products may impede SSF innovation. National registries require plant varieties to be homogenous, which farmers' varieties are not. Labeling requirements may in some cases restrict the distribution of new products by placing too much of a burden on farmers in the form of transaction costs. Participants gave examples of how certification and procedural costs have constrained innovation pathways. One example was cited of a farmer innovator who missed an opportunity to launch her soap business because of the long timeframe required for certification.

The relationship between intellectual property rights (IPR) and SSF innovation is far from straightforward. It was suggested that national plant variety protection (PVP) legislation developed in accordance with UPOV (the primary multilateral institution for establishing a PVP system) does not presently appear to affect poor and marginalized SSFs' breeding efforts. Participants did however discuss how UPOV might be impeding SSF innovation indirectly. UPOV is focused on a particular model of agricultural innovation—one where scientists breed new varieties and farmers adopt them—ignoring the dynamics of farmer seed networks and on-farm breeding. Farmers conduct extensive on-farm field trials and often integrate 'modern' varieties of seed into their diverse mixtures. One participant explained that while on-farm breeding and seed exchange may not be impeded directly through the application of PVP to 'formal' sector breeding outputs, this model locks-in and reinforces the particular view that plant breeding is done by professional breeders for the benefit of farmers as passive recipients. This paradigm is then reflected in other policies and research priorities, such as the availability of funding for ex-situ conservation and 'formal' sector research efforts compared with on-farm conservation and farmer-led research. The G8 Alliance also requires a country to adopt UPOV 1991 to be a recipient of funds under the Alliance, thus complicating national multi-stakeholder dialogue on whether or not this is an appropriate legal instrument for the country or if any modification (e.g. exempting certain areas, crops or populations) is desirable.

International trade agreements that push for strengthened national patent systems in addition to the implementation of UPOV 1991 may restrict farmers' seed saving and on-farm breeding. It was suggested that patents might have a more direct negative impact on SSF innovation and exacerbate existing power imbalances between SSF breeders and 'formal' sector breeders.

Participants also discussed the effect of increased market access on SSF innovation. New market opportunities may drive one type of innovation—the development of new commercial products—but do not encourage or support innovation that provides both private gain for the SSF and global public benefit for which they receive no remuneration. On the contrary, farmers are encouraged to participate in export-oriented or cash crop economies in lieu of more diversified farming systems hosting both inter- and intraspecific diversity. This is not the optimum outcome from a global food security perspective. Both agrobiodiversity and diversified farming systems are of vital importance to global food security, yet this value is not reflected in market prices. Innovative SSFs are essentially subsidizing global welfare without incentives or external support.

Participants highlighted that historically, farmers have benefited in the short-term from export-driven policies, such as subsidies for particular crops, until markets become saturated and crash. Farmers have incentives to alter production practices to suit national priorities, and it becomes difficult to diversify production once incentives are in place. Monocultural production practices are vulnerable to price volatility and environmental stresses such as the influx of new pests and diseases. The loss of agrobiodiversity at all levels, along with the erosion of associated local knowledge systems and farming practices, impedes future agricultural innovation both on and off the farm. This diversity can never be recovered.

Lastly, policies that are developed without whole systems in mind pose challenges to SSF innovation. One participant highlighted a case where an effort to subsidize organic fertilizers for the benefit of SSFs incited a mass importation of organic fertilizers from outside the country, which then had a negative impact on prices for supplying farmers. Policies need to be developed not only in consultation with SSFs but with stakeholders from different sectors, and with an appreciation of the interconnectedness of agriculture, environment, health and economic policy spheres.

Policies that support SSF innovation

Participants discussed key elements of an enabling environment and types of policies most supportive of SSF innovation. An enabling environment for SSF innovation requires: farmers' active participation in the development of policies at all levels, recognition of farmers' land and resource rights and the institutionalization of farmer-led research within agricultural research and development organizations. Characteristics of supportive policies in general are those that:

- Encourage the active maintenance and development of local crop varieties;
- Recognize the value of local knowledge systems and capacity of farmers to experiment and innovate to adapt to changing conditions;
- Help farmers organize; and
- Provide the technical support and space for farmers' participation in agricultural research endeavors.

Legal recognition of farmers' land and resource rights was flagged as a prerequisite for SSF innovation. Only when rights are recognized and enforced may farmers enter into truly equitable partnerships with formal sector institutions and organizations. It was highlighted by one participant that recognition as a legal entity is also necessary for sharing in the benefits arising from the use of genetic diversity and local knowledge. Another participant highlighted that local protocols and regional laws recognizing farmers' rights can be useful in gaining their acknowledgement at higher levels. Yet another highlighted how the court system in Mexico is recognizing indigenous communities' rights to receive prior informed consent for access to genetic resources. Using a rights-based approach to support SSF innovation may be a powerful tool for national governments implementing other policies conducive to SSF innovation.

Many participants emphasized the importance of funding farmer-led research initiatives. Farmer-led research supports on-farm experimentation, promotes agrobiodiversity conservation, development and management and social justice and is a major driver of SSF innovation. Providing space and a mechanism for direct access to funding ensures that local people can decide on their own research priorities and set their own agenda. Outside actors may support the establishment of a farmer committee with a funding mechanism, capitalized by different funding sources including national governments and donor organizations interested in supporting SSFs in diverse agroecosystems with different compositions of genetic diversity, species diversity and management practices. This type of support will reinforce existing innovation networks and draw out those who require initial support to participate. There was wide agreement that resources need to be put towards building capacity to innovate and strengthening knowledge systems rather than capturing innovations and knowledge.

Alternative types of IPR regimes may support SSF innovation. Registries for farmers' varieties are in place in India, Thailand and the Philippines that recognize farmers as breeders, unlike UPOV. In India, the registration of farmers' varieties has spurred on-farm conservation initiatives but generally the group was not aware of any in-depth analysis of impact. Alternative seed certification schemes and registries that do not force standardization and uniformity upon informal seed systems may be more supportive of SSF innovation, validate farmers' experimentation and breeding, and help protect against misappropriation of resources and knowledge.

The establishment of agrobiodiversity conservation areas or protected landscapes supports SSF innovation. The designation of special areas may increase recognition of the public good aspect of the resources and environmental and public health services that SSFs provide, and encourage the active and dynamic maintenance of the inputs to innovation processes in the future. Formally recognized areas also increase opportunities for coordination among SSFs and create a space for the creation of tools for benefit sharing, the use of collective trademarks and the establishment of micro-enterprises and ecotourism ventures that generate income. The Potato Park was recognized as one such success, but there need to be more of these.

The formal recognition and celebration of cultural heritage may be another way to support SSF innovation. Support for local food movements, culinary traditions and the establishment of UNESCO intangible heritage sites for local crop diversity link agrobiodiversity conservation with nutrition and culture and have great potential to raise public awareness of the value of SSF innovation, helping to shift the discourse within international fora.

Supporting innovation fairs and awards were recognized as an important strategy for increasing public recognition of SSF innovation. Policy makers are invited to see the kind of innovation being developed on-farm and farmers can share innovations amongst themselves. Fairs have helped to raise awareness that farmers are highly capable of breaking new ground and farmers receive valuable social recognition for their expertise. Awards offer opportunities to commercialize successes and scale them up and out, although it was noted that such awards recognize only certain types of SSF innovation (often in line with government priorities) and give only individual recognition.

Supportive policy measures may include others that incentivize the production of farmers' varieties such as direct subsidies or tax exemptions for production, public procurement of local varieties, or anti-competition laws constraining the market power of larger firms. These alternatives were not discussed in-depth, but are consistent with the broader conversation on creating an enabling environment for SSF innovation—focused on raising recognition of the value of agrobiodiversity and the diversity of small-scale farming systems themselves.

5. Opportunities for mainstreaming SSF Innovation

The final topic discussed was how to strategically integrate the concept of SSF innovation into national level policies and into the policy discourse within international fora.

Mainstreaming the concept of SSF innovation into the discussions and decisions of international fora working on innovation policy, intellectual property, trade, food security and nutrition will require finding strategic points of entry. Participants identified international bodies, conventions and protocols most relevant to SSF innovation. Participants are currently engaged in a wide range of international policy fora, highlighting the benefit of creating a common understanding of SSF innovation systems with which to carry forward into these negotiations.

The connections between SSF innovation and traditional knowledge, food security, nutrition, cultural heritage and climate change adaptation need to be made more explicit in policy discussions. The complementarity between the concept of SSF innovation and the International Treaty on Plant Genetic Resources for Food and Agriculture (the International Treaty) and the Convention on Biological Diversity (CBD) were discussed at length. In particular, there is significant overlap between the concepts of SSF innovation and Farmers' Rights (Article 9 of the International Treaty), and mainstreaming the concept of SSF innovation may aid attempts to domesticate the Treaty. In addition to this, the implementation of the Nagoya Protocol was recognized as an opportunity for national governments to incorporate SSF innovation into their national innovation policies, whilst the WIPO Development Agenda may also represent an underutilized avenue for mainstreaming the concept of SSF innovation.

Choice of language is important. The term 'innovation' was recognized as a buzzword garnering significant international attention, which could be used strategically to raise awareness of, legitimize and valorize the work of SSFs onfarm. However, participants suggested that the language used to discuss SSF innovation systems should not be radically divorced from existing language used by the WIPO Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC), the provisions of the CBD on customary use of and traditional practices associated with biodiversity (Article 10.c) and the International Treaty provisions on Farmers' Rights (Article 9). The IGC influenced the language used in the Nagoya Protocol to the CBD, which may represent a critical entry point for this work because it is a timely moment for the concept of SSF innovation systems to be included in national governments' implementation of the Protocol.

It was recognized that Geneva-based organizations governing trade (WTO, which also administers the TRIPS Agreement) and intellectual property (WIPO), as well as the UPOV Convention, hold more weight than the International Treaty and the CBD and Nagoya Protocol. Provisions for protecting Farmers' Rights, Traditional Knowledge and Access and Benefit Sharing have relatively weak enforcement compared with the TRIPS Agreement and the Agreement on Agriculture (AoA), for example. International agreements without compliance mechanisms have less leverage to encourage their implementation into national law. It will be critical to find entry points to mainstream SSF innovation in the discussions on innovation in agriculture taking place at the WTO and WIPO. With growing membership and its common link to aid, UPOV is also a Geneva-based organization to be monitored.

There is also a need to influence the discourse used within national innovation committees. It was highlighted that in the absence of alternative visions of innovation in agriculture, the OECD and World Bank exercise disproportionate influence over national innovation policy. The language used by these institutions reflects their understanding of agricultural innovation as a system (i.e. beyond a conventional technology transfer perspective.) They promote innovation platforms that bring together cross-sector multi-stakeholder groups to develop innovation strategies. They do not, however, address the unequal power dynamics within groups and the innovative capacity of SSFs is not recognized.

Source: Small-Scale Farmer Innovation systems: Report on the First Expert Consultation

By: Quaker United Nations Office
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Social protection and agriculture to break the cycle of rural poverty

Hundreds of millions of rural families are trapped in a cycle of hunger, poverty and low productivity that causes unnecessary suffering and impedes agricultural development and broader economic growth. Breaking this cycle requires actions in two complementary domains: social protection and growth in the productive sectors of the economy. As agriculture remains the most important productive sector for rural people in many developing countries, linking social protection with agricultural development is a potentially powerful means of breaking the cycle of rural poverty.

Many developing countries increasingly recognize that social protection measures are needed to relieve the immediate deprivation of people living in poverty and to prevent others from falling into poverty when a crisis strikes. Social protection can also help recipients become more productive by enabling them to manage risks, build assets and undertake more remunerative activities. These benefits spread beyond the immediate recipients to their communities and the broader economy as recipients purchase food, agricultural inputs and other rural goods and services.

This article was drawn from previously published materials entitled *The State of Food and Agriculture Social protection and agriculture: Breaking the cycle of rural poverty* by FAO, Rome. Refer to the source box towards the end of this article for a complete reference to the original article.

Social protection measures will help break the cycle of rural poverty and vulnerability, when combined with broader agricultural and rural development measures. This introductory chapter provides a conceptual framework that highlights the linkages among social protection, rural household consumption and production, and poverty alleviation. It focuses on rural poverty and emphasizes the importance of agriculture and agricultural development as the primary pathways out of poverty for millions of family farms. It briefly introduces concepts related to social protection and summarizes related recent trends in low- and middle-income countries.

Subsequent chapters review evidence regarding social protection and agriculture. Although few studies have directly examined the linkages between social protection and agriculture, many rigorous impact evaluations have been conducted on social protection programmes in rural contexts. These provide a robust body of evidence on three key issues: (i) the effectiveness of social protection measures in alleviating deprivation and food insecurity among the poor, (ii) the extent to which social protection enhances the productive potential of poor agricultural households, and (iii) the extent to which the benefits received by programme participants generates incomes that can "spill over" into the local economy and community. The report evaluates the factors that contribute to the heterogeneity of programme impacts and discusses what they imply for programme design and how agricultural policies can be tied in with social protection programmes more directly. It concludes with a discussion of policy and governance recommendations.

Social protection measures can also ease the economic and social dislocations that accompany economic growth and agricultural transformation, reducing social and economic inequalities, promoting decent work and fostering inclusive and sustainable growth. But social protection can only offer a sustainable pathway out of poverty if there is growth in the economy. In most low- and middle-income countries, agriculture remains the largest employer of the poor and is a major source of livelihoods through wage labour and own production for household consumption and the market. Poverty and its corollaries—malnutrition, illness and lack of education—limit agricultural productivity. Hence, addressing social protection and agricultural development in an integrated way offers synergies that can increase the effectiveness of both.

Linking poverty, social protection and agriculture

Figure 1 illustrates the conceptual linkages among rural poverty, social protection and agriculture. It begins with a stylized rural household at the centre that makes decisions about what to produce and consume based on the initial quantity and quality of livelihood resources the household controls or has access to and the expected revenue from multiple economic activities, as well as private and public transfers. Household livelihood resources are often described as comprising five types of assets/resources: physical, human, social, financial and natural. Physical assets for a typical rural household engaged in agriculture may include land, machinery and livestock. Human resources include the health, nutrition and education status of all family members, which together determine the family's ability to work and earn incomes. For many poor households, human resources are their main source of income. Social resources refer to networks—such as reciprocal friendship and kinship ties, funeral and savings associations, producer groups and other community groups—that enable the household to manage risk and engage with the wider community. Financial assets include household savings and access to formal and informal sources of credit. Natural resources relate to the quality and stability of the natural environment, such as soil, water and climate conditions.

For most rural households, especially small family farms, production and consumption decisions are closely intertwined, with the family providing most of the labour used on the farm, and consuming part of the output for its own needs. These household production and consumption decisions determine the levels of household income, savings and investment. These, in turn, link households to markets through the sales and purchases of food, inputs, labour and other goods and services. These household and market activities, in turn, influence the stock of physical and financial household assets, allowing them to accumulate in good times or requiring them to liquidate assets to survive.

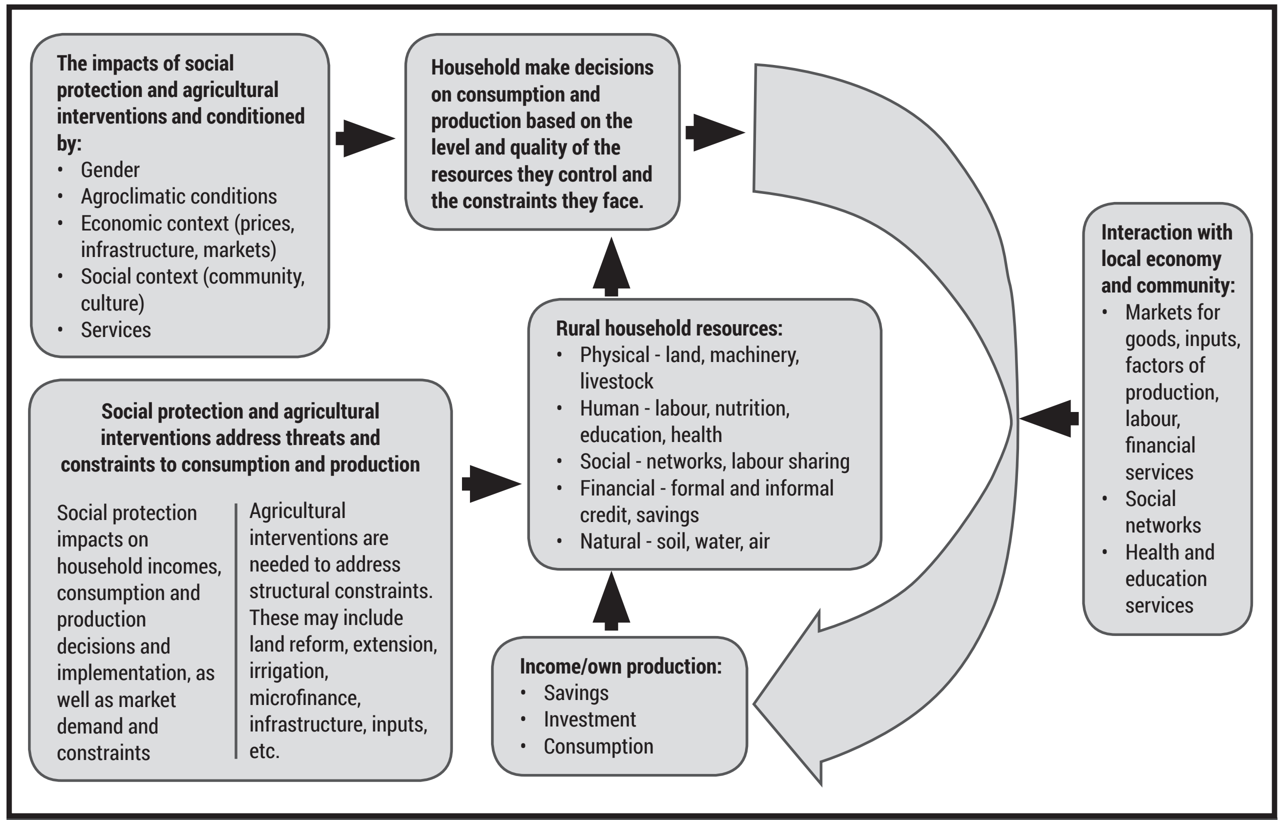

Figure 1. Social protection linkages to household consumption and productions activities and the local economy.
Source: FAO

Social protection programmes and agricultural interventions influence household decision-making processes at several different points. Social protection measures, such as cash or in-kind transfers, can directly enhance the human resources and productivity of recipients by enabling them, for example, to consume healthier diets, access appropriate medical care and take advantage of educational opportunities. By relaxing credit and liquidity constraints, social protection transfers can enable households to invest in new and more productive activities and to build assets and enhance resources. When transfers are regular and predictable, they can enable recipients to undertake investments that may otherwise be too risky. Formal social protection measures can relieve pressure on informal insurance mechanisms and social reciprocal networks under stress.

As social protection measures change the production, consumption and entrepreneurial activities of recipient households, these activities will have spillover effects on the local economy by stimulating demand for local goods and services. At the same time, agricultural interventions can promote productivity growth by addressing constraints that limit poor households' access to land and water resources, inputs, financial services, advisory services and markets. Such interventions to ease supply-side constraints are also needed to help transform increased local demand due to social protection into local economic growth, rather than inflation. In this sense, agricultural interventions and social protection are complementary, meeting people's basic needs and enabling them to take advantage of opportunities to become more productive, while also facilitating market-based activities, thus creating a virtuous circle of human well-being, agricultural growth and economic security.

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Source: The State of Food and Agriculture: Social protection and agriculture: breaking the cycle of rural poverty
By: FAO, Rome
2015

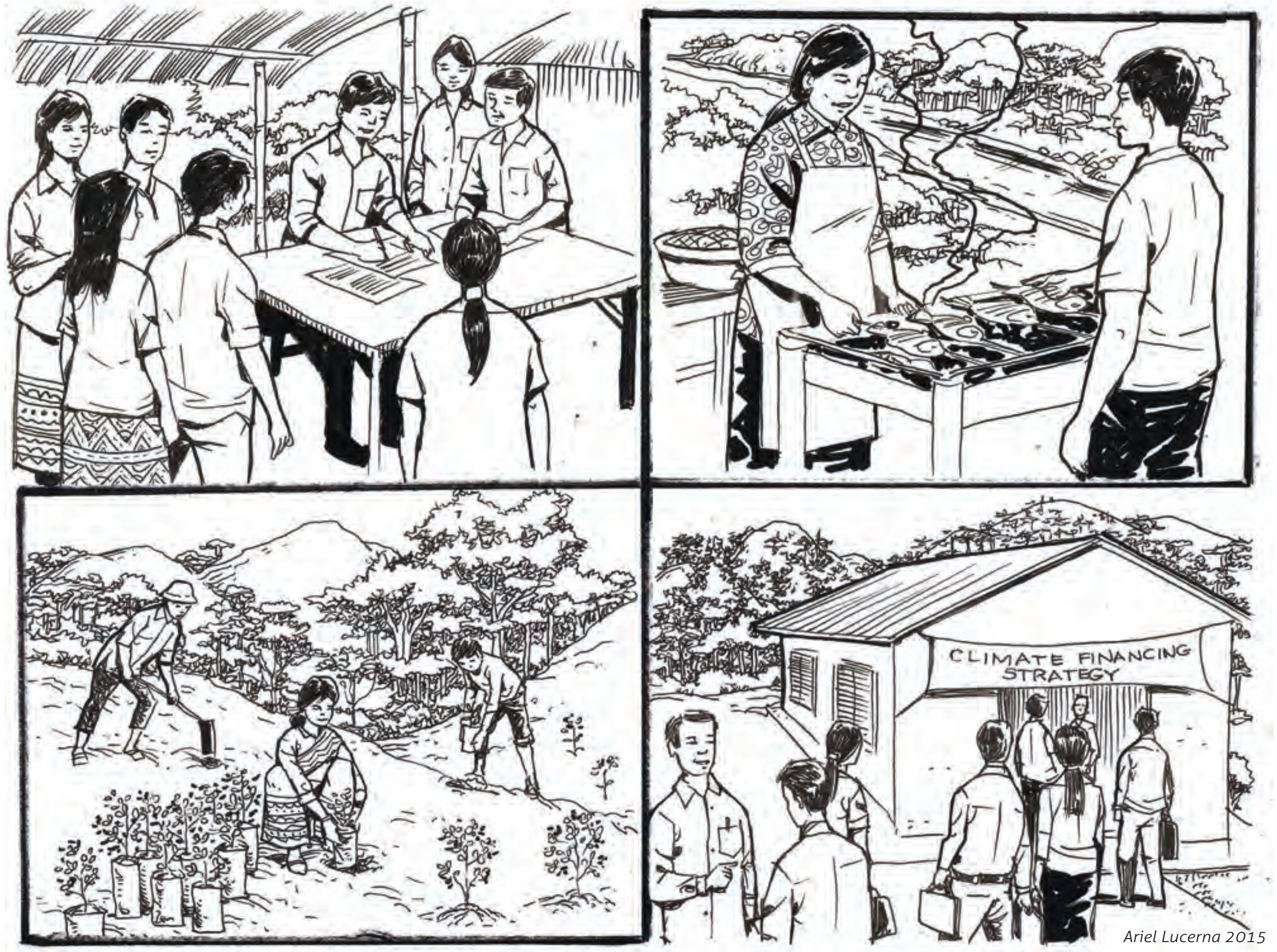
chapter 6

Tools and methodologies to support climate-smart futures

- Climate-smart agriculture prioritazion framework
- Community-based adaptation in practice: A global overview of CARE International's practice of Community-based Adaptation (CBA) to climate change
- Community based adaptation and its gender implications
- Participatory action research
- Participatory action research: Getting started
- Participatory action research: Understanding points and aims
- Participatory action research: Empirical research inputs
- Common challenges to participatory action research
- Community-based adaptation to climate change: An overview
- The application of participatory action research to climate change adaptation
- Climate service for farmers

Tools and methodologies to support climate-smart futures

Adaptation to climate change requires thinking and acting beyond immediate needs to address tomorrow's challenges. But this requires forward planning and long-term livelihood adaptation all levels – from national to community level. This final chapter highlights strategies for tackling key challenges related to climate change as outlined by donors and development organizations inlcuding the Asia Development Bank and USAID. For example, energy use and generation cause more than half of all Asia's greenhouse gas emissions. Yet Southeast Asia is a region endowed with favorable conditions for promoting renewable power generation. Clean energy projects have the potential to mitigate energy-related CO2 emissions, often at very low levels of investment compared with the costs of adaptation. This chapter outlines approaches and strategies for tackling climate change at community and national level to realize and take advantage of opportunities, as well as take stock of challenges, ahead.



Ariel Lucerna 2015

Framing adaptation:
a continuum of approaches

If there is one clear lesson from the experience of adaptation responses to date it's that there is no one clear lesson. Responses to climate change encompass countless sectors and different communities. Some involve detailed understanding of the emerging impacts; others, only the vaguest notion that a vulnerable community will be under climatic stress. Some involve a deliberate attempt to cope with climate change; many contribute to adaptation without intending to.

How then do we approach the messiness and diversity that characterizes adaptation? The first thing to realize is that no one model for framing adaptation efforts will be completely satisfactory. Any set of criteria for sorting adaptation initiatives can and will be critiqued. A framework is important only insofar as it is useful in making a particular point; in other cases, we may carve up the problem differently. Here we introduce a framework of approaches to adaptation based upon how closely those approaches target specific climate change impacts.

This article was drawn from *Weathering the storm: Options for framing adaptation and development* by Heather McGray, Anne Hammill, Rob Bradley with E. Lisa Schipper and Jo-Ellen Parry. Refer to the source box towards the end of this article for a complete reference to the original article.

Our framework makes a key point: rather than draw a sharp distinction between adaptation and development, we instead place them on a continuum. This enables users to better understand the overlap between efforts, and should allow policymakers and funders more latitude in designing and implementing adaptation programs.

Mapping adaptation efforts

Two roughly distinct perspectives inform how people approach the challenge of adaptation: one focuses on creating response mechanisms to specific impacts associated with climate change, and the other on reducing vulnerability to climate change through building capacities that can help deal with a range of impacts. The first approach uses understood impacts as a starting point for distinguishing between adaptation and "normal" development. However, making this distinction can be technically and conceptually difficult and has been critiqued for neglecting the real causes of vulnerability. A more vulnerability-focused approach, on the other hand, starts by targeting the underlying factors that cause climate change to be harmful (Ribot 1995). Such an approach may fall outside the mandate of climate change policies, and can also appear massive in scope.

In practice, of course, many instances of adaptation fall between the extremes of vulnerability and impacts foci: actions are taken with a specific type of impact in mind, but nevertheless involve activities with more general benefits in reducing vulnerability. One way of framing this diversity is as a continuum between "pure" development activities on one hand and very explicit climate change measures on the other.

Figure 1 represents one way of mapping out adaptation efforts—that is, actions undertaken to limit the harm associated with climate change. On the left-hand side of the continuum, the most vulnerability-oriented adaptation efforts overlap almost completely with traditional development practice, where activities take little or no account of specific impacts associated with climate change, and have many benefits in the absence of climate change.

On the far right, highly specialized activities exclusively target distinct climate change impacts, and fall outside the realm of development as we know it. Their benefits will materialize only in the event of climate change. In between lies a broad spectrum of activities with gradations of emphasis on vulnerability and impacts. The continuum can be roughly divided into four types of adaptation efforts (from left to right):

1. Addressing the drivers of vulnerability

At the left end of the spectrum, activities are fundamentally about bolstering human development. These activities focus on reducing poverty and addressing other fundamental shortages of capability that make people vulnerable to harm, regardless of whether the stressors that can lead to harm are related to climate change. Example activities include livelihood diversification efforts, literacy promotion, women's rights initiatives, and even projects that address HIV/AIDS.

Very little, if any, attention to the specifics of climate change is paid during these interventions; these activities buffer households and communities from the effects of climate change simply because they buffer them from nearly all sources of harm. Many of these activities are capacity-building activities that strengthen individuals' abilities to take action. One capability often fostered is the ability to "cope," or take short-term action to ward off immediate risk from climatic events (e.g., taking shelter to survive a storm, or saving enough food to survive a drought).

1 Addressing Drivers of Vulnerability	2 Building Response Capacity	3 Managing Climate Risk	4 Confronting Climate Change
Uganda: Providing women with crossbred goats and instruction in graze-free feeding (*Karamoja Agropastoral Development Programme*) **Bangladesh:** Diversification of livelihood strategies in areas vulnerable to flooding (**South** *South* North) Cuba: Vaccination program to eradicate diseases in low-income areas (*Cuban Ministry of Health*)	**Brazil:** Participatory reforestration in Rio de Janeiro's hillside favelas to combat flood-induced landslides (*City of Rio de Janeiro*) **Mongolia:** Reinstating pastoral networks to foster appropriate rangeland management practices in arid regions (*National University of Mongolia*) **Tanzania:** Reviving traditional enclosures to encourage vegetation regeneration and reduce land degradation (*Ministry of Natural Resources & Tourism, Tanzania*)	**Tanzania:** Monitoring salinization of drinking water and drilling new wells to replace those that are no longer usable (**South** *South* North) **Mali:** Teaching farmers to collect climate data and integrate it into their planting decisions (*Government of Mali / Swiss Agency for Development and Cooperation*) **Bangladesh:** Using nationally standardized risk assessment procedures to develop a community adaptation plan of action (*Local Government*)	**Indonesia:** Managing coral reefs in response to widespread coral bleaching (*WWF*) **Nepal:** Reducing the risk of glacial lake outburst floods from Tsho Rolpa Lake (*Government of Nepal*)

VULNERABILITY FOCUS ⟷ IMPACTS FOCUS

Figure 1. A continuum of adaptation activities: From development to climate change.

Often, poverty and other core reasons for vulnerability must be dealt with before more impact-oriented adaptation efforts can be effective. In other cases, however, vulnerability-oriented efforts can be conducted concurrently with more impacts-oriented initiatives. In our data set, 65 percent of the examples that we have characterized as addressing the drivers of vulnerability also included activities that more directly focused on impacts associated with climate change.

However, because climate change effects are not taken into account, some interventions at the left of the continuum run the risk of maladaptation. For example, while diversifying agricultural livelihoods typically reduces vulnerability and strengthens resilience, diversification efforts that introduce crop varieties that cannot withstand increased drought conditions could undermine development gains over the longer term if droughts become more frequent. Likewise, while coping capacity can be critical for surviving short-term dangers, repeated coping may undermine long-term adaptation.

We find that activities that address the foundations of vulnerability frequently are located in projects that were termed "serendipitous" adaptation in Section II. However, some of these efforts are incorporated into cases of discrete adaptation work, frequently in combination with activities that fall elsewhere on the Figure 1 continuum.

2. Building response capacity

In this zone of the continuum, adaptation focuses on building robust systems for problem solving. These capacity-building efforts lay the foundation for more targeted actions and frequently entail institution-building and technological approaches familiar to the development community. Examples include the development of communications systems and planning processes, and the improvement of mapping, weather monitoring, and natural resource management practices.

These activities may have many benefits other than adaptation to climate change, but they typically occur in sectors more directly relevant to climate change than literacy, women's rights, or HIV/AIDS efforts. Though climate change information does not play a central role in the work, awareness of climate change is a reason for prioritizing it over work in other areas. Activities that build response capacity may map to any of the models identified in Section II. Many are development activities to which an adaptive function was ascribed only after the fact, but many such activities are also incorporated into discrete adaptation efforts. Adaptation initiatives that must contend with high levels of uncertainty will often have resilience-building activities that fall into this category.

With building response capacity, the extent to which activities are targeted toward specific impacts is limited, either by limited ability to predict expected impacts or by limitations on other capacities needed for highly targeted action. For example, in Rwanda, efforts to "climateproof" hydropower production hit a roadblock because of uncertainty as to whether climate change will bring more or less rainfall. Adaptation efforts are moving forward by strengthening hydropower operations in general, with the expectation that these strengths will help the power sector adapt to specific effects of a changing climate, whatever they may be. In the meantime, more reliable power production helps to address numerous non–climate-related needs in Rwanda.

3. Managing climate risk

When adaptation efforts focus more specifically on hazards and impacts, an important framework for action is provided by the concept of climate risk management (CRM). CRM refers to the process of incorporating climate information into decisions to reduce negative changes to resources and livelihoods (Hellmuth et al. 2007). This framework accommodates the fact that often the effects of anthropogenic climate change are not easily distinguished from the effects of events and trends within the historic range of climate variability. The CRM approach encourages managing current climate-related risks as a basis for managing more complex, longer-term risks associated with climate change (UNDP 2002).

Use of climate information distinguishes the CRM approach from typical development efforts, though the success of CRM may have strong development implications and vice-versa. Many disaster-response planning activities fall into the CRM category, as do many technological approaches (e.g. drought-resistant crops). Climate-proofing projects most often fall into this category, though many discrete adaptation projects also focus on CRM. In the dry lands of Kenya, a CRM approach is being used to prepare for future droughts, which are expected to intensify as climate changes.

The success of CRM depends heavily upon the availability of climate information, and is enhanced when climate change predictions can be made with relatively high certainty and precision. If adaptation initiatives plan too concretely based on risk assessments that turn out later to have been inaccurate, investments may be wasted, and maladaptation could result.

4. Confronting climate change

For a small set of examples of adaptation in our review, actions taken focus almost exclusively on addressing impacts associated with climate change. Typically, these actions target climate risks that are clearly outside of historic climate variability, and have little bearing on risks that stem from anything other than anthropogenic climate change. For example, communities that relocate in response to sea level rise mainly fall into this category, as do many responses to glacial melting. Radical or costly policy and technological approaches that address unprecedented levels of climate risk also belong in the highly targeted category. Few of these approaches have been seen to date, but efforts in the Himalayas to prevent harms from glacial melting, and Australia's overhaul of water allocation rules after six years of drought probably are signs of things to come.

Because measures that are highly targeted at climate change impacts do not address non-climate change challenges, they tend to require new approaches that fall outside of the relatively well-understood set of practices that we might think of as a development "comfort zone." This level of innovation usually takes the form of a discrete effort, and is often both costly and fundamentally challenging to cultural and political norms. After all, even with the clearest, most certain climate predictions in hand, it isn't easy to decide to leave the island where your family has lived for generations, or to accept that the land your community has farmed for centuries is becoming too dry to sustain agriculture. Moreover, initiatives that relocate whole groups of people or that launch large, untested engineering endeavors come with large price tags that require a high level of political will.

As such, many measures in this continuum zone take on an extreme or "last-ditch" quality, and many people, quite rightly, wish to avoid them. This is one reason we see so few activities from this category in our set of examples. A more important reason, however, is that, at least for the moment, climate change effects and "normal" climate variability are difficult to disassociate. Therefore, we see more adaptation approaches that address climate change and other sources of risk together using a CRM approach. Given the current state of climate change, highly "impacts-targeted" activities also require long-term planning, since the most clearly distinguishable impacts of climate change are still years or decades from being felt in many places.

However, it is also clear that the need for highly impacts targeted climate change action can in many cases be reduced by the success of other types of adaptation efforts, and by work to stabilize greenhouse gas concentrations in the atmosphere. We can think of the boundary on the continuum between Managing Climate Risk and Confronting Climate Change as a threshold that moves right if greenhouse gas mitigation and climate adaptation are successful, shrinking the scope of impacts-targeted action needed. To the extent that climate adaptation and greenhouse gas mitigation fail, the threshold moves left, expanding the scope of impacts-targeted activity, since the direct affects of climate change will be felt more directly by more people.

This is not to say that climate change-specific action can be avoided entirely. Science shows us with increasing precision that we are already "committed" to a certain amount of global warming, which has direct implications for many people in many places. Places such as Nepal are moving forward with proactive planning for some specific eventualities. That these instances remain relatively few indicates that society will need more than climate predictions to prompt proactive planning for those consequences of climate change that will be most unique and potentially most difficult to address.

Using a framework of adaptation approaches

It is important to emphasize that the continuum presented in Figure 1 describes a set of approaches to adaptation, not the specific circumstances or the type of impact faced. The continuum categorizes adaptation efforts according to whether vulnerability or impacts are emphasized in the approach taken. Most other frameworks for analyzing adaptation have distinguished among efforts based upon sectoral divisions, impacts addressed, ecosystem characteristics, or the scale (location, national international, etc.) of the intervention. It is also important to emphasize that, as befits a continuum, the lines between the categories are blurry. As such, it is often difficult to decide whether a given activity is best described, for example, as building response capacity or managing climate risk. In truth, there is much more variation in the extent to which an activity may target a specific climate change impact than can be described with four zones. However, we believe we have characterized four roughly distinct possible relationships between an adaptation effort and a specific impact associated with climate change.

The typology developed here does not attempt to rank the different types of adaptation; rather, it simply attempts to describe present adaptation efforts in developing countries. The typology also should not be thought of as a series of stages over time, with highly targeted climate change activities as the ultimate goal. (In fact, the need for highly targeted climate change activities is something we would all like to avoid, to the extent possible.) It is clear, however, that addressing vulnerability drivers, building response capacity, and managing climate risk do augment one another. There are many examples where adaptation initiatives incorporate elements of two or three of these approaches.

Placing individual instances of adaptation along this spectrum is at best an inexact science. However, as Figure 2 illustrates, we find the bulk of the experience to date focuses on the “messy middle” of building capacity and managing climate risk, where adaptation is neither wholly focused on climate change impacts nor completely oriented toward the underlying drivers of vulnerability. Approximately one-fifth of the cases studied fall into the vulnerability drivers category; they are essentially “pure” development activities. Quite likely, our study substantially underestimates the extent of adaptation underway as a result of this type of intervention, given the many similar efforts not yet labeled “adaptation.” Conversely, very few instances of highly climate change-specific adaptation measures have been recorded.
What determines the type of adaptation activity? Two factors appear to predominate in shaping the characterization of an adaptation response: the existing capacity of those responding and the certainty of information about climate impacts.

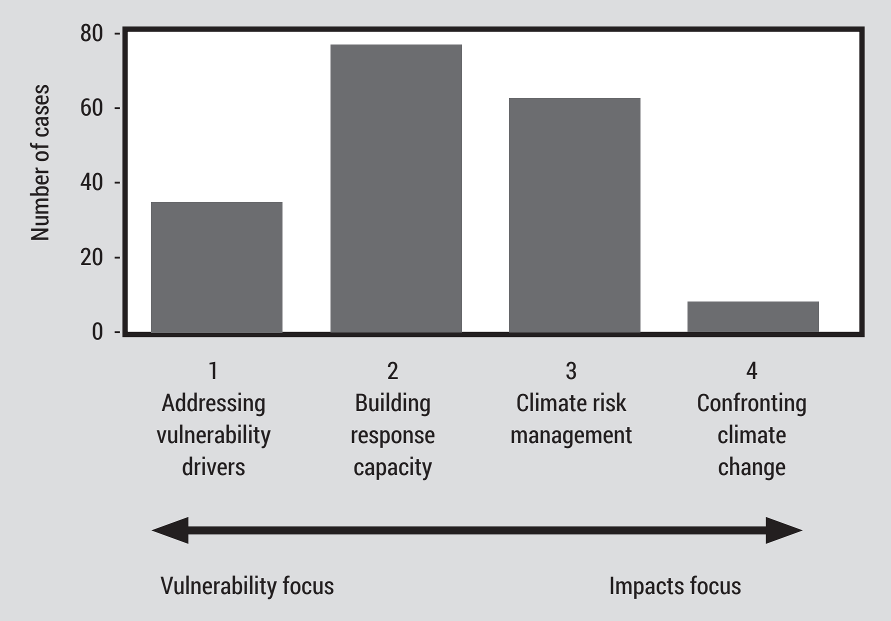


Figure 2. Characterization of cases of adaptation type.

Lower levels of capacity necessitate greater investment in addressing underlying sources of vulnerability (i.e., adaptation efforts more to the left of the continuum). Higher certainty regarding climate change prediction enables efforts to more directly target specific impacts (i.e., on the right of the continuum). However, it is important to note that neither of these drivers has a linear relationship to how closely adaptation efforts may target a specific impact. For example, in a case where storm risks are very well understood, a CRM approach may be impossible if basic communications infrastructure does not exist. In this case, the broader capacity building involved in creating the communications infrastructure would be an adaptation priority, even though information may exist that could support more impacts-targeted efforts.

Notably, the type of impact does not always drive the response taken. A country or community faced with a given change in climate can select from among a range of responses. For instance, as coral reefs die off from ocean warming, coastal communities may be more exposed to storm surges. One response may be to build artificial reefs to mitigate surges—an activity that would fall on the right of the continuum. Conversely, building more permanent and robust housing and infrastructure may enhance the resilience of coastal communities while fitting a broader set of development needs—placing it more centrally along the continuum. Taking a response from the far left of our continuum, broad capacity building may be needed to equip the affected communities to make the appropriate choices for facing these and any other consequences associated with climate change.

It seems likely that other factors, such as the specificity, severity, and immediacy of an impact, as well as people’s perceptions of risk and access to information, may play a role in determining the appropriate extent to which interventions should target specific impacts. Further exploration of such factors is needed to better understand when to home in on specific impacts and when to build more broadly applicable capacities.

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Source: Weathering the storm: Options for framing adaptation and development

Authors:
Heather McGray, Anne Hammill, Rob Bradley with E. Lisa Schipper and Jo-Ellen Parry

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Community-based adaptation in practice:

A global overview of Care International's practice of Community-based Adaptation (CBA) to climate change

The development of CARE's approach to CBA CARE's approach to integrating climate change into development work has grown from the bottom up. Field-level practitioners were the first to articulate the problem, as they witnessed and struggled to contend with the impacts of climate change in vulnerable communities. In response, CARE has developed a series of climate change strategies and tools, based on what practitioners have experienced and

This article was drawn from *Community-based Adaptation in Practice: A global overview of CARE International's practice of Community-Based Adaptation (CBA) to climate change* by Sally King. Refer to the source box towards the end of this article for a complete reference to the original article.

Although community-based interventions are necessarily situated at local level, it is crucial to recognise that CBA also demands and promotes action at all other levels to achieve systemic and long-term change. CARE's CBA framework provides a holistic analytical approach for communities to plan adaptation actions that are informed by climate science as well as by local observations of climate change. It builds the capacities of local civil society and government institutions to better support communities' adaptation efforts. It also addresses underlying causes of vulnerability, such as poor governance, gender-based inequality over resource use, or access to basic services, by influencing the policy and enabling environment.

learned over the past few years. The most notable of these resources are described below to show how our approach has developed through time.

1. CARE's Community-Based Adaptation (CBA) framework was first presented in 2009. The framework describes a range of enabling factors (climate-resilient livelihoods, disaster risk reduction (DRR), local adaptive and organisational capacity development, an enabling national policy environment, a good knowledge of climate change, and the addressing of underlying causes of vulnerability) that need to be in place for effective community-based adaptation to occur. These enabling factors are achieved through the use of four interrelated strategies:

- promotion of climate-resilient livelihoods strategies
- disaster risk reduction strategies to reduce the impact of hazards on vulnerable households
- capacity development for local civil society and government institutions
- advocacy and social mobilisation to address the underlying causes of vulnerability.

2. The Climate Vulnerability and Capacity Analysis (CVCA) Handbook (2009) was, and continues to be, an extremely popular practitioner tool. The approach provides insights into the complex array of climatic, environmental, social, economic and political factors that determine people's vulnerability to climate change. This information then enables the community, project staff, partners and policy makers to target resources and interventions where they are needed most.

3. CARE published its CBA Project Toolkit in 2011. This is a step-by-step guide to designing, implementing and monitoring CBA projects. It includes a set of project standards and proposed milestones and indicators to help practitioners plan activities and track the progress made in building adaptive capacity. These resources reflect the fact that adaptation is a dynamic process that involves mapping the assets and conditions that must be in place for communities to manage current climate variability as well as adapt to longer-term climate change.

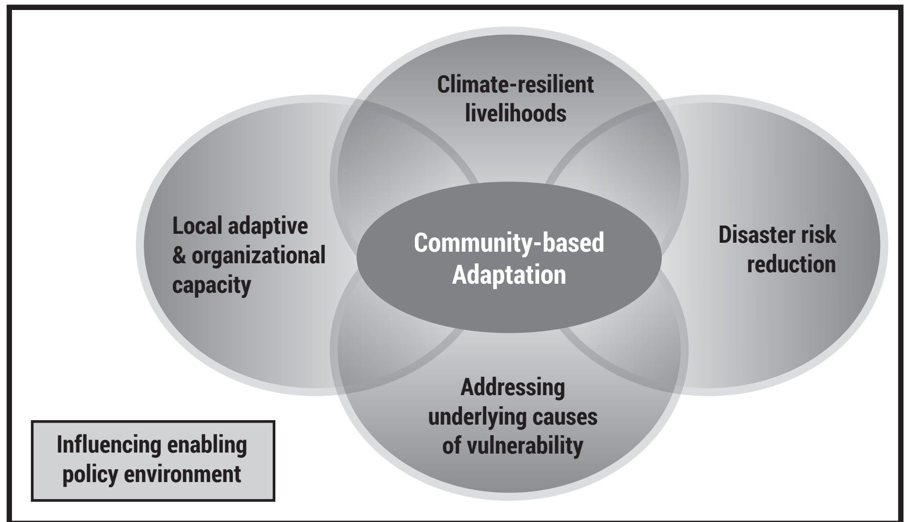

Figure 1. The original 2009 CARE CBA 'flower' diagram.

4. CARE produced another toolkit in 2011, directly responding to the needs of practitioners wanting to integrate climate change adaptation measures into other development sectors, such as disaster risk reduction (DRR) and food and nutrition security. This toolkit enables climate change information, climate vulnerability analysis and climate-resilient livelihood options and technologies to be introduced into ongoing development projects, thus improving their effectiveness and longer-term sustainability.

5. Many developments in CARE's approach to CBA have come directly from project experience. For example, in 2011 CARE Vietnam piloted a new approach to participatory planning for watershed management that proved extremely effective and of relevance for most types of CBA project. The Visioning Approach is now widely used within CARE to encourage community engagement with adaptation planning.

6. In 2012, CARE, in partnership with the International Institute for Environment and Development (IIED), published the Participatory Monitoring, Evaluation, Reflection and Learning (PMERL) for Community-Based Adaptation Manual. The manual promotes community-led monitoring, evaluation and learning processes that contribute to the impact and sustainability of adaptation activities beyond the life of a CBA project.

7. Global research and learning programmes have also contributed to CARE's approach to CBA. For example, in 2012, the Adaptation Learning Programme for Africa (ALP) produced a brief about using multi-stakeholder learning events as a mechanism for participatory sharing, and interpretation of, climate information and forecasts—Decisionmaking for climate resilient livelihoods and risk reduction: a participatory scenario planning (PSP) approach.

8. ALP also adapted the original CBA 'flower' diagram (see figure 2) to emphasise the use of climate information, and the uncertain nature of climate risk, in guiding project/community decision-making as the critical distinguishing features of adaptation work.

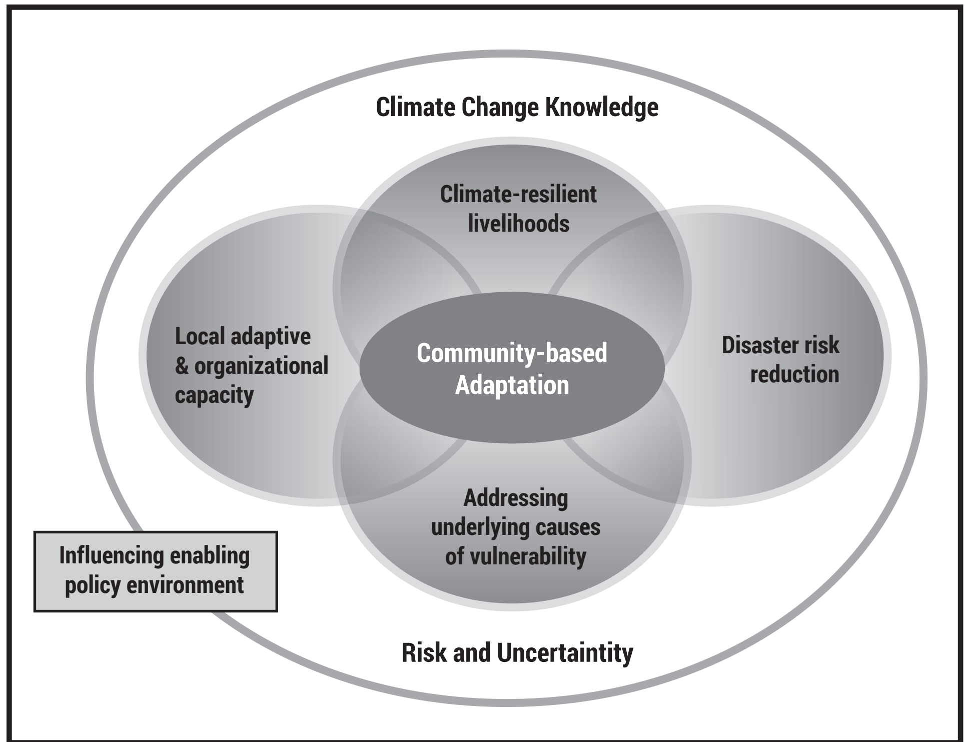

Figure 2. The updated CARE CBA 'flower' diagram.

Since 2009, when CARE first developed its Community-Based Adaptation (CBA) framework, significant progress has been made in terms of refining CARE's practice of CBA. The regional case studies and global learning shared in this paper have highlighted some of these developments in the approach. This section aims to consolidate lessons learned, in order to move forward in CARE's understanding of CBA and to inform the current process of updating our key climate change tools and resources for practitioners.

Good practice in CBA

The case studies demonstrate that there is no one single model of good practice for CBA projects. The climatic, environmental, social, economic, and political context surrounding a community determines the design, implementation and possible outcomes of CBA processes and activities. However, looking across the examples shared in this paper, and our programme portfolio as a whole, some key lessons about what works well, across many different contexts, have emerged. NB: This paper does not include an exhaustive list of good practices, but highlights those most prominent in CARE's projects. Further documentation and assessment of CBA projects is required to fully identify and evaluate all such emerging good practices. To summarise CARE's learning on good practice in CBA and some possible implications for practitioners involved in CBA, we have identified some key lessons learned (see following table).

Lessons learned Implications

1. Adaptive capacity

Delivering on all four strategies, and all levels, of the CBA framework is crucial for building adaptive capacity effectively and sustainably. Adding the overarching components of 'climate information' and 'managing risk and uncertainty' helps to focus community/project decision making around preparing for, and managing, future climate change risks, despite their uncertain nature. Regardless of context, CBA projects must ensure that they are working on all four CBA framework strategies, at all levels, so that project outcomes are effective and last beyond the project lifetime. If one strategy is neglected, all other activities could be negatively affected. The use of climate information in guiding project/community decision-making is the critical distinguishing feature of adaptation work, as opposed to 'sustainable development' practice in general. Without regular and ongoing access to good-quality and locally relevant climate information, communities and other stakeholders are unable to adequately plan for, or respond to, the impacts of climate change. If communities and stakeholders are aware of the uncertain nature of predicting future climate risks, they can focus on building and maintaining flexible, proactive and responsive adaptation processes and activities.

2. Equitable approaches

Participatory and rights-based approaches can help to ensure that adaptation outcomes are effective and sustainable. They also help to ensure that project activities do not exacerbate existing inequalities and vulnerabilities, and that they fulfil the needs of the most vulnerable groups. Inequality in access to rights, resources and power lies at the root of poverty and vulnerability. Neither can be reduced effectively without taking action to understand and address these inequalities. By using gender, and other types of power and vulnerability,

Lessons learned	Implications
1. Adaptive capacity Delivering of all four strategies and all levels of the CBA framework is crucial for building adaptive capacity effectively and sustainably. Adapting the overeaching components of 'climate information' and 'managing risk and uncertainty' helps to focus community project decision-making around preparing for, and managing, future climate change risks, despite their uncertain nature.	Regardless of context, CBA projects must ensure that they are working on all four CBA framework strategies, at all levels, so that project outcomes are effective and last beyond the project lifetime. If one strategy is neglected, all other activities could be negatively affected. The use of climate information in guiding project/community decision-making is the critical distinguishing feature of adaptation work, as opposed to 'sustainable development' practice in general. Without regular on-going access to good-quality and locally relevant climate information, communities and other stakeholders are unable to adequately plan for, or respond to, the impacts of climate change. If communities and stakeholders are aware of the uncertain nature of predicting future climate risks, they can focus on building and maintaining flexible, proactive and responsive adaptation processes and activities.
2. Equitable approaches Participatori and rights-based approaches can help to ensure the adaptation outcomes are effective and sustainable. They also help to ensure that project activities do not exacerbate existing inequalities and vulnerabilities, and that they fulfill the needs of the most vulnerable groups.	Inequality in access to rights, resources and power lies at the root of poverty and vulnerability. Neither can be reduced effectively without taking action to understand and address these inequalities. By using gender, and other types of power and vulnerability, analyses in CBA projects, we can help to ensure that adaptation outcomes are more effective and sustainable, and do not reinforce or exacerbate existing inequalities. Generating adaptation strategies together with communities and other local stakeholders improves the uptake and sustainability of the process because communities develop a strong sense of ownership and their specific priorities are met. As a minimum, project activities should promote the equal participation of men and women and, ideally, meets lasting transformative change in gender relations as part of building the adaptive capacity of the whole community.
3. Working with partners External partners working with a community, for example providing resources and knowledge, are often a key factor in a successful CBA project. Working with existing civil society networks and platforms can facilitate the local to national-level advocacy requirements of CBA projects (usually around adaptation planning, financing of context-specific topics such as land rights for women or other marginalised groups.	The critical importance of sourcing and communicating good quality and accessible climate information in adaptation projects relies on building relationships with external partners who hold this information. Facilitating participatory multi-stakeholder workshops, as promoted in the Participatory Scenario Planning (PSP) approach, can create mutual interest in sustaining a lasting relationship between communities and service/information providers. Similarly, private sector or local/national government partnerships can strengthen and increase the impact of CBA activities by providing services, and financial or political support, to influence the wider enabling environment. However, external partners may leave their own interests and priorities. Partnerships can only succeed when these priorities overlap well with those of the communities. Rather than trying to create 'CBA-specific' advocacy networks or processes, identify existing civil society organisations whose priorities integrate well with those of the communities. Developing mutually beneficial relationships will help to strengthen the collective voice and increases the impact of the project's advocacy efforts.
4. Integration with formal planning processes. CBA is not something that communities do alone — it is a multi-level approach to adaptation that puts vulnerable people and their priorities first, but action is required at all levels (household, community, local and national).	CBA projects can establish strong partnerships with local and national government agencies, which can provide support for communities' adaptation priorities, build local technical capacity, and include adaptation in development, budgeting, agricultural extension on disaster risk reduction (DRR) plans and processes. Through embedding community-level adaptation priorities into existing plans, structures and institutional mechanisms, the impact of the project is expanded and strengthened. This formal recognition of CBA priorities can help ensure the sustainability of multi-level relationships and information channels beyond the lifetime of a project.

.... table continued

Lessons learned	Implications
Communities are able to integrate their context-specific adaptation plans into formal government plans and processes.	Principles A, D and E of the proposed Joint Adaptation Principles (outlined in section 3,3) directly promote CBA as a mechanism for generating and implementing equitable and pro-poor adaptation policies, activities and planning. CBA projects could use this framework to engage and influence national government to better integrate CBA into national level plans.
5. Building local capacity The development, application, and sharing of effective participatory tools and approaches in CBA can help to build the capacity of local actors and promote the continuation of adaptation activities and processes after the lifetime of the project.	Facilitating relationship-building between targeted communities and various relevant stakeholders, in participatory and mutually beneficial training activities and capacity-building processes, helps to ensure the continuation of activities after the project ends. All four of the above lessons learned demonstrate the critical role of working with multiple stakeholders at all levels to successfully build the adaptive capacity of communities and their wider national context. Participatory and community-based tools, such as CARE's Community Vulnerability and Capacity Assessment (CVCA), Village Visioning tool, Participatory Scenario Planning (PSP), and Participatory Monitoring, Evaluation, Reflection and Learning (PMERL) manual, also contribute to the process of capacity-building and promote the local ownership of the adaptation planning.

analyses in CBA projects we can help to ensure that adaptation outcomes are more effective and sustainable, and do not reinforce or exacerbate existing inequalities. Generating adaptation strategies together with communities and other local stakeholders improves the uptake and sustainability of the process because communities develop a strong sense of ownership and their specific priorities are met. As a minimum, project activities should promote the equal participation of men and women and, ideally, create lasting transformative change in gender relations as part of building the adaptive capacity of the whole community.

3. Working with partners

External partners working with a community, for example providing resources and knowledge, are often a key factor in a successful CBA project. Working with existing civil society networks and platforms can facilitate the local to national-level advocacy requirements of CBA projects (usually around adaptation planning, financing or contextspecific topics such as land rights for women or other marginalised groups). The critical importance of sourcing and communicating good-quality and accessible climate information in adaptation projects relies on building relationships with external partners who hold this information. Facilitating participatory multi-stakeholder workshops, as promoted in the Participatory Scenario Planning (PSP) approach, can create mutual interest in sustaining a lasting relationship between communities and service/information providers. Similarly, private sector or local/national government partnerships can strengthen and increase the impact of CBA activities by providing services, and financial or political support, to influence the wider enabling environment. However, external partners may have their own interests and priorities. Partnerships can only succeed when these priorities overlap well with those of the communities. Rather than trying to create 'CBA-specific' advocacy networks or processes, identify existing civil society organisations whose priorities integrate well with those of the communities. Developing mutually beneficial relationships will help to strengthen the collective voice and increase the impact of the project's advocacy efforts.

4. Integration with formal planning processes

CBA is not something that communities do alone — it is a multi-level approach to adaptation that puts vulnerable people and their priorities first, but action is required at all levels (household, community, local and national). Communities are able to integrate their context-specific adaptation plans into formal government plans and processes. CBA projects can establish strong partnerships with local and national government agencies, which can provide support for communities' adaptation priorities, build local technical capacity, and include adaptation in development, budgeting, agricultural extension or disaster risk reduction (DRR) plans and processes. Through embedding community-level adaptation priorities into existing plans, structures and institutional mechanisms, the impact of the project is expanded and strengthened. This formal recognition of CBA priorities can help ensure the sustainability of multi-level relationships and information channels beyond the lifetime of a project. Principles A, D and E of the proposed Joint Adaptation Principles directly promote CBA as a mechanism for generating and implementing equitable and pro-poor adaptation policies, activities and planning. CBA projects could use this framework to engage and influence national government bodies to better integrate CBA into national-level plans.

5. Building local capacity

The development, application, and sharing of effective participatory tools and approaches in CBA can help to build the capacity of local actors and promote the continuation of adaptation activities and processes after the lifetime of the project. Facilitating relationship-building between targeted communities and various relevant stakeholders, in participatory and mutually beneficial training activities and capacity-building processes, helps to ensure the continuation of activities after the project ends. All four of the above lessons learned demonstrate the critical role of working with multiple stakeholders at all levels to successfully build the adaptive capacity of communities and their wider national context. Participatory and community-based tools, such as CARE's Community Vulnerability and Capacity Assessment (CVCA), Village Visioning tool, Participatory Scenario Planning (PSP), and the Participatory Monitoring, Evaluation, Reflection and Learning (PMERL) manual, also contribute to the process of capacity-building and promote the local ownership of adaptation planning.

Refining CARE's CBA approach

CARE's CBA tools and resources are in the process of being updated to reflect these emerging lessons on good practice. Our experiences in CBA have also revealed some issues that are missing from, or need to be better integrated into, our existing set of tools and resources. The main issues identified, and outlines of how we hope to address each issue, are summarised in the following table.

Gender equality and women's empowerment

Although it is relatively easy to engage women, in terms of CBA project participation, it is much more difficult to effect long-term and structural change in gender relations, and women's empowerment outcomes at household, community or national levels. Integrating CARE's gender continuum and Women's Empowerment Framework approaches into CBA project design, to prioritise strategies that can effect lasting transformative change in gender relations as part of building the adaptive capacity of the whole community. Climate information: While much progress has been made on integrating climate information into decision-making, many challenges remain in terms of access to, and usability of, such information for the poorest or most vulnerable groups, as well as around effective communication and the dissemination of information. The Adaptation Learning Programme for Africa (ALP) has already highlighted the critical importance of climate information in adaptation, by adding it as an overarching element in the CBA Framework. Further research into 'how best' to simplify, communicate and share climate information is ongoing. Ecosystem approaches: Rural communities directly depend upon natural resources, and on the products and services provided by healthy ecosystems. However, the focus of CARE's existing

Issues	Next Steps
Gender equality and women's empowerments: Although it is relatively easy to engage women, in terms of CBA project participation, it is much more difficult to effect long-term and structural change in gender relations, and women's empowerment outcomes at households, community or national levels.	Integrating CARE's gender continuum and Women's Empowerment Framework approaches into CBA project design, to prioritise strategies that can effect lasting transformative change in gender relations as part of building the adaptive capacity of the whole community.
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Ecosystem approaches: Rural communities directly depend upon natural resources and on the products and services provided by healthy ecosystems. However, the focus of CARE's existing adaptation tools and approaches is primarily around socio-economic analysis, with an assumption that natural resources will be adequately considered as part of this process.	CARE is a member of the Ecosystems and Livelihoods Adaptation Network (ELAN) that seeks to promote the integration of sound ecosystem management with socio-economic approaches to climate change adaptation. The networks is working on a position paper to establish the foundation of such an integrated approach.
Financing CBA: The processes of building adaptive capacity and adaptation planning can be expensive. They require consistent government/partner support and necessarily need to effectively involve vulnerable and marginalised groups, which adds additional cost and challenges.	To research different financial mechanisms that could support adaptation planning and activities from social protection schemes that act as a buffer during climate-related disasters to local savings and loans groups and micro-insurance schemes, etc. Some of these mechanisms are already in use within other development projects but have not yet been evaluated in terms of managing climate-related risk.
CBA as a process: Since building adaptive capacity is a continuous process of understanding, planning for and responding to an uncertain changing climate, we need to better reflect this in our tools and resources. Integration into general development practices: Practitioners have mentioned that climate change adaptation is often misunderstood as 'yet another development sector', and not seen as a critical risk affecting all development work.	To consolidate and link existing CARE tools to better reflect the process of building adaptive capacity. The 'methodology for CBA planning' outlined in the Vietnam case study, is just one example of how projects are already beginning to combine multiple tools within CBA processes. To integrate climate change adaptation into CARE's project cycle management approaches to ensure that project design and decision-making processes are directly informed by climate information gathered during vulnerability analysis.

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Financing CBA

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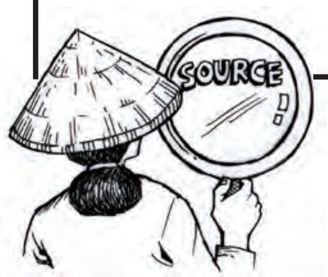
Source: Community-based Adaptation in Practice: A global overview of CARE International's practice of Community-Based Adaptation (CBA) to climate change
By: CARE International
2014

For further information on any of the projects described in this paper, or if you would like to contribute to, or support CARE's work on CBA, please visit: www.careclimatechange.org or email info@careclimatechange.org.



Community based adaptation and its gender implications

Community-based adaptation

Community-based adaptation includes any group-based approach that

- requires collective action and social capital,
- incorporates information about long-term climate changes and their anticipated impacts into planning processes,
- integrates local knowledge and perceptions of climate change and risk-management strategies,
- emphasizes local decisionmaking processes,
- accords with community priorities and needs, and
- provides poverty reducing or livelihood benefits.

This article was drawn from *Gender, Climate Change, and Group-Based: Approaches to Adaptation* by Julia A. Behrman, Elizabeth Bryan and Amelia Goh, and is used with permission from the International Food Policy Research Institute. Refer to the source box towards the end of this article for a complete reference to the original article.

The literature on collective action and participatory development suggests that community-based adaptation depends on the ability of communities to work collectively through social networks to manage the risks of climate change. Some of the preconditions of successful community-based adaptation include well-defined rules that conform to local conditions (for example, those dealing with the appropriation and provision of resources, conflict resolution, monitoring mechanisms, and sanctions for violators of the rules). Moreover, external agencies must recognize the right of communities to organize, and local organizations should have strong linkages to other supporting institutions and governance structures, such as agencies and organizations involved in economic development, social protection, and risk management. Another important principle for effective collective action is that all members of the group participate in decisionmaking and rule-setting. In practice, however, the extent to which the needs, interests, and priorities of all members of the community are incorporated depends on local power structures. Several other factors may also affect the success of collective action depending on the local context, including group size, the heterogeneity of group members, and the adaptability of the institution to change.

While lessons from the literature are useful in guiding community-based adaptation, climate change may complicate collective action by introducing new shocks into communities or by intensifying existing ones. For example, communities may use collective action to build resilience to drought that occurs every decade but may be unprepared for severe droughts that occur more frequently than that. In addition, collective adaptation requires location-specific information on anticipated climate changes and appropriate responses, which may not be available in many communities. In many cases, climate change may introduce a considerable degree of uncertainty that complicates collective decisionmaking.

The gender implications of community-based adaptation

The broader impact of community-based adaptation ultimately depends on who is able to participate. Given a growing body of evidence indicating that climate change and climate shocks differentially affect men and women, gender should be an important consideration in the adaptation process. The literature indicates that adaptation is an inherently "political" process that produces "winners" and "losers." The scope of participation may differ among members taking part in community-based adaptation. In many contexts, women lack access to the assets necessary for participation, such as land, financial capital, information, or social capital. Women, especially from poor households, are also more likely to face time constraints that limit their ability to participate.

The literature also points to gender differences in setting priorities through group-based approaches to adaptation. Women often have greater responsibility for household food production and preparation, whereas men have greater involvement in market-oriented production. Thus, women may prioritize community-based strategies that promote long-term food and nutrition security, such as community-level projects, trainings, and facilities focused on food storage and preservation or the development of community gardens with micronutrient-rich food. Similarly, given women's focus on household consumption of water, fuel, and fodder (as previously discussed), women may prioritize community-level investments in domestic water supplies, such as rainwater collection or other types of community water storage, and alternative energy sources, such as biomass, biogas, solar power, improved stoves, and battery-operated lamps. Moreover, given women's domestic workloads, including caring for children, the sick, and the elderly, they are likely to prefer community-based adaptation strategies that allow them to stay close to home.

Assets are essential to poor peoples' ability to cope with climatic shocks and to adapt to the long-term impacts of climate change. Physical assets can be sold to help households cope with shocks, and other assets—such as secure land and water rights, agricultural technologies, livestock, knowledge, and social capital—can assist households in adapting to greater variability in agricultural production resulting from climate changes.

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Source: Gender, Climate Change, and Group-Based Approaches to Adaptation

Policy Note/September 2014
By: Behrman, J. A., E. Bryan, and A. Goh. 2014. Gender, Climate Change, and Group-Based Approaches to Adaptation. IFPRI Policy Note. Washington, DC: International Food Policy Research Institute. http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128766.

Participatory action research

Participatory action research (PAR) is a reflective process of progressive problem-solving led by individuals working with others to improve the way they address issues and solve problems.

PAR is generally applied within social learning contexts, where multiple actors collectively construct meanings (problem definition, objectives) and work collectively toward solutions (Maarleveld and Dangbégnon 1999; Pretty and Buck 2002). Lewin, a pioneer of action research, describes the PAR process as "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action" (Lewin 1946; see also Figure 1). Iterative cycles of organizational or community-level action and reflection make change processes more robust and effective by ensuring that systematic learning and sharing take place, by fostering continuous adjustment of actions to align them with agreed-upon objectives, and by empowering the actors themselves to learn and adapt. PAR combines two primary activities: research and a facilitated process of social learning guided by a shared vision or set of goals to be achieved.

This article was extracted from Section 4.B of the book entitled *The Application of Participatory Action Research to Climate Change Adaptation: A Reference Guide* by Laura A. German, Anne-Marie Tiani, Ali Daoudi, Tendayi Mutimukuru Maravanyika, Edward Chuma, Nathalie Beaulieu, Henri Lo, Cyprian Jum, Nontokozo Nemarundwe, Edward Ontita, Giselle Yitamben and Victor Orindi, IDRC (2010). Refer to the source box towards the end of this article for a complete reference to the book.

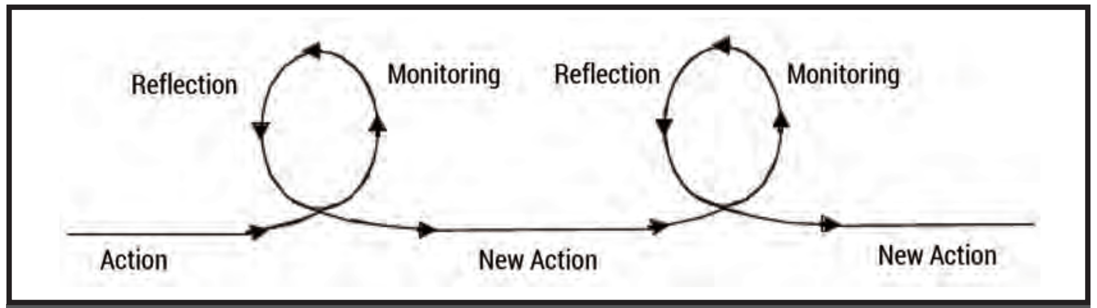

Figure 1. Graphical illustration of the iterative cycles of learning and doing in the PAR process

It is often assumed that PAR is a tool that is useful only for solving local-level problems and social issues. However, PAR may be carried out within research and development organizations as a process of institutional change, by policymakers who are interested in taking an adaptive approach to policy implementation, or by local communities as they seek solutions to common problems (German and Stroud 2007). It may also be used to enable biophysical solutions to work better by ensuring that diverse value systems are considered, and by facilitating an adaptive approach to change (Hagmann 1999; Hagmann and Chuma 2002). German and Stroud (2007) differentiate between participatory action research (PAR) and action research (AR). According to them, PAR is about "getting change to work," while AR is about "understanding the nature of change processes and distilling lessons of use to a wider audience striving to solve similar problems elsewhere." Whereas PAR aims to empower the actors themselves to identify key development bottlenecks and to experiment with different approaches for addressing and ultimately breaking through bottlenecks, AR enables a better understanding of the key elements to successful processes of development and social change. Differences between participatory action research, action research, and conventional research are summarized in Table 1.

This Reference Guide makes no such differentiation, as it combines the three "learning approaches" in the PAR process. However, it is useful to understand that the action research team has a set of unique roles relative to the other stakeholders involved in the change process as a result of its interest in distilling general lessons from specific change processes

Table 1. Characteristics of different learning approaches (German and Stroud, 2007)

Characteristics	Participatory Action Research	Action Research	Conventional (Empirical) Research
1. Purpose	Solve localized problems	Derive lessons for the global community on how to solve certain types of problems	Characterize current or future situations and trends.
2. Tools	Interactive (facilitation, negotiation, participatory monitoring and evaluation)	Extractive (monitoring the performance of scientific indicators, impact assessment, process documentation) and interactive PAR methods.	Extractive (a large body of methods derived from diverse social and biophysical sciences)
3. Carried out by whom?	Actors in a charge process (farmers, leaders of organizational change, policy-makers, urban residents).	Researchers with an interest in 'process' (how transformationoccurs); change agents interested in deriving generalizable lessons.	Researchers: At times, change agents will also turn conventional research either for inputs (i.e. technologies) or to evaluate the impact of change process they facilitated.

for a wider audience (the "research" in PAR). The uniqueness and complementarity of these different approaches will therefore remain apparent to many readers as they move through different sections of the guide. It will also be apparent in the way in which PAR and action research teams are discussed—namely, as distinct yet interdependent entities in the change process. For an illustration of how the research and the action are related to one another over time, see Figure 2. This separation of research from action should not be taken as something endorsed by the authors; it is simply a didactic means to illustrate the role of research within a PAR process. In practice, researchers should move seamlessly between their roles as participants in a change process (facilitation, empirical research, or partnership) and in more reflective, analytical work about the change process itself. The boundaries between these two "layers" are therefore fuzzy. One of the greatest challenges researchers face is to understand this "seamlessness" between research and action—and to move beyond the tendency to either lose themselves in "development" cycles or undermine the continuity or attention given to PAR by failing to drop their own research agendas.

In addition to differentiating PAR from action research, it is important to differentiate PAR from participatory rural appraisal (PRA) and from participatory research (PR). PRA is a set of analytical tools that enables villagers to do their own analysis of the realities that affect them, with a view to making use of such information. It is therefore not a comprehensive approach to enabling change, but may be employed within a change process to identify problems (for example, participatory mapping as a tool for participatory diagnosis of degradation "hotspots"), to establish baselines, or to identify constraints and opportunities (for example, periods within annual labour calendars when there is room for accommodating more labour-intensive activities). Participatory research, on the other hand, is research that is conducted as an equal partnership between external "experts" (generally, scientists) and members of a community. For research to qualify as participatory, it should be characterized by a reciprocal appreciation of each partner's knowledge and skills at each stage of the project, and research outcomes should be useful to the community. In this respect, PAR could be considered one form of participatory research. However, PAR tends to be much broader than participatory research in its iterative nature and, therefore, in its ability to enable more far-reaching change (social or system-wide transformation, rather than just the testing of technologies).

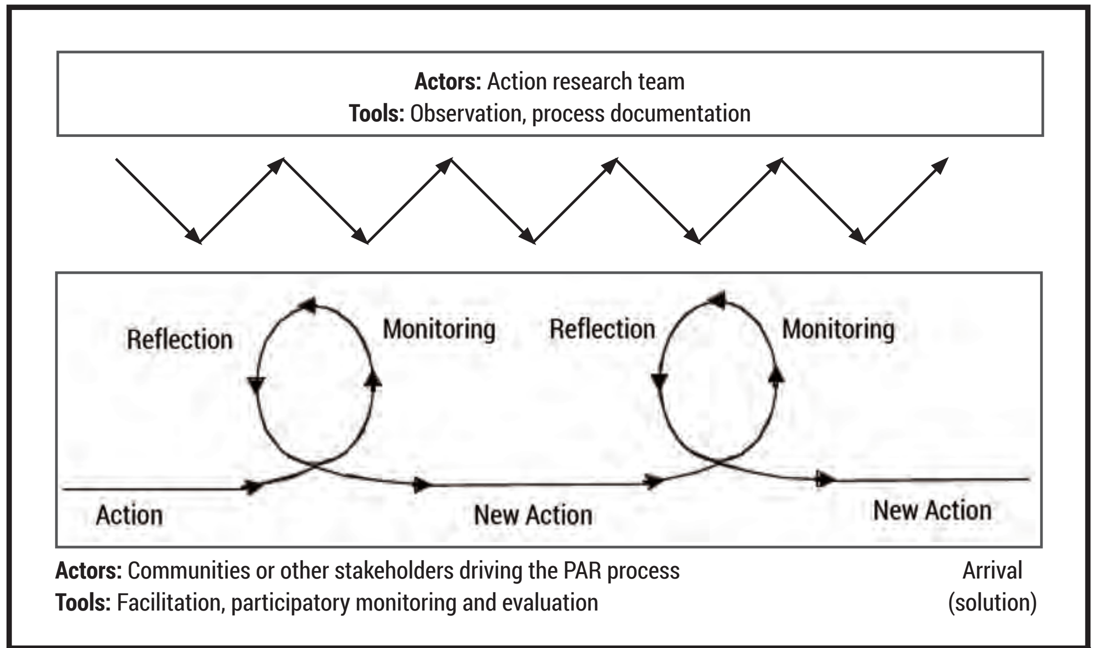

Figure 2. Illustration of the relationship between action research (upper box) and PAR (lower box).

Furthermore, failure to ensure local ownership of the process, and to place the nexus of power and decision-making squarely in the hands of the intended beneficiaries, subjects it to abuse:

> ***At its best, the process can be liberating, empowering and educative, a collegial relationship that brings local communities into the policy debate, validating their knowledge. At its worst, it can degenerate into a process of co-option of local communities into an external agenda, or an exploitative series of empty rituals, imposing fresh burdens on the community's time and energy and serving primarily to legitimize the credentials of the implementing agency as 'grassroots oriented'.***

This challenge and the abuses it gives rise to led, earlier on, to attempts to classify participatory research into different forms (Biggs 1989). Figure 3 depicts the inherent tension that tends to exist in participatory research between science quality on the one hand and improved development on the other—a tension that more often than not tends to result in contractual and consultative modes of research.

In PAR, the same tension exists, but efforts to put communities squarely in control of the process mean that the process tends to lead to an emphasis on development impact over research per se. The challenge is always there for researchers to ensure rigour in the learning process and distill findings or lessons of wider relevance (Box 1)—and thus leverage the potential of PAR in informing wider communities of practice.

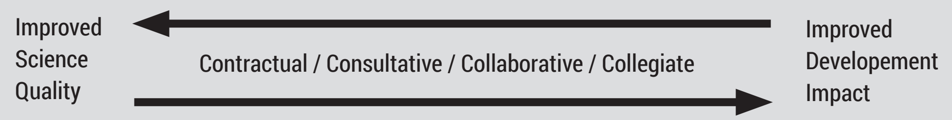

Figure 3. Different types of participatory research (Biggs, 1989).

Box 1. The question of validity in action research and PAR

Effort to put communities in control of the change process has created a certain discomfort among those in the long-established conventional or empirical research tradition. This has caused some to question the validity of action research and PAR. The questions often asked include, "How can one derive general lessons about change from happenings within a specific context, given the cultural, institutional, and ecological particularities of each setting?" "How can claims to validity be supported when there are no bearings to hold methods constant through time?" Some authors claim it is simply a matter of keeping one's "intellectual bearings in a changing situation" (Checkland and Holwell 1998:13). These authors suggest that claims to validity require a "recoverable research process based on prior declaration of the epistemology in terms of which findings count as knowledge will be expressed" (Checkland and Holwell 1998:9). In other words, one cannot engage in change without prior declaration of the scope of research and how it will be carried out. Elements of this process include prior declaration of an area of concern, a framework of ideas, and a methodology (Checkland 1991; Checkland and Holwell 1998). An area of concern is a topic around which the research is organized — in this case, processes or strategies for enhancing people's adaptability to climate change.

The broader framework of ideas may include a conceptual understanding of the deficiencies of current practices, support services and policies on adaptation to climate change, and/or a set of guiding values (e.g. equity, sustainability) known to be deficient in current practice. It may also be a body of theory informing change (i.e. property rights and collective action theory, political ecology, ecosystem theory). As the effectiveness of change is largely determined by the actors themselves, the above authors would probably be comfortable with locally established aims and participatory evaluations of the change process as evidence of its effectiveness. Researchers with a more conventional approach to scientific validity may require research questions and hypotheses to be clearly stated up front and held constant, lessons to be derived from cross-site or cross-case comparison (within one or more sites), and conventional research to validate claims of effectiveness of the change process.

PAR for climate change adaptation

The successful application of PAR in the past to solve problems in complex socio-ecological systems (Colfer 2005; Hagmann and Chuma 2002) and to facilitate institutional change (Elliot 1991; Hagmann 1999) makes many of the lessons and approaches readily applicable to climate change adaptation. However, it is important to also distil the features of PAR that make it uniquely suitable and those that limit its applicability to climate change adaptation. Key features of climate change and adaptation likely to shape the application of PAR include:

- Climate change is a slow variable, with changes playing over the medium to long term
- "Adaptive capacity" can best be assessed over long time scales
- The predictability of climatic change is limited
- Inaccuracy and/or incompleteness of local and scientific knowledge on climate change and its impacts
- Nested levels of socio-political organization and response influence sensitivity and adaptive capacity
- Complexity (of climate change impacts, solutions)

While many of these characteristics are not unique to climate change, they interface in important ways with the PAR methodology. Perhaps the biggest weakness of PAR derives from the mismatch between "slow variables" (climate change, adaptation) that play out over long time frames, and the short-term thinking that often characterizes human decision-making (Holling and Meffe 1996). The long time scales over which the impacts from climate change are manifest, and over which "adaptations" may be evaluated, limits human capacity to respond to the appropriate stimuli (see, for example, Abel and Langston 2001). On the other hand, if PAR is viewed not only as a tool for solving particular climate-related problems, but as a tool for fostering sustained learning and adaptation over time through partnerships between at-risk communities, government institutions and other actors, it becomes a tool which (together with its corollary, adaptive management) is uniquely suitable to climate change adaptation. It is the ongoing and capacity building nature of action research processes that make it appropriate in the context of ongoing climatic change and variability. The benefits of PAR for addressing challenges related to complexity and nested levels of socio-political organization are similar: prescriptive solutions are unlikely to work, requiring an adaptive approach to change that builds upon successes and failures in charting a more desirable future.

As for the limited predictability of climate change and limitations in local and scientific knowledge, PAR can strengthen understanding by building upon the complementarities of local and scientific knowledge and fostering a more nuanced understanding of systems. These complementarities may cover aspects such as what is observed (content), what matters (motivation), and time and space dimensions (scale) (DeWalt 1994). Scientific knowledge tends to be stronger at deriving understanding at larger spatial scales, while local knowledge is often stronger at understanding the particularities of a given location. Regarding temporal dimensions, local and scientific knowledge each have their strengths in observing change over longer time frames. However, scientists may be able to predict future climatic change better, while communities tend to be more versed in historical change and how to deal with uncertainty based on their own experience with past climatic changes and related adaptive strategies—as well as their understanding of what worked and did not work, and why. While PAR may be beneficial in bringing these two bodies of knowledge together around a common problem, it is important to recognize that ultimately it is the characteristic of humility that enables an effective partnership between scientists and local communities. Within PAR, it is important to inculcate a common understanding that all knowledge is partial and in part subjective, and that it is through partnership, social learning and active monitoring that the unknowns will diminish relative to what is known.

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Participatory action research: Getting started

Team building and partnership

Primary aims

Team building and partnership are essential to initiating change, as they set stronger foundations for all that follows. The basic objectives and requirements for team and partnership building are similar. The main purpose is to establish the conditions required to ensure the future success of the project, to put in place an effective team composed of individuals with complementary skills and establish a set of sensitized and committed partners. It is also useful for becoming more familiar with one another—key motivating factors, strengths, weaknesses and complementarities—and to build rapport. This helps to highlight the interdependence of different team members or partners. Team and partnership building should not be seen as a one-off activity; rather, it is a continuous process that requires active management as the project evolves.

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It is important to note that there is a distinction between building a team and building a partnership. They are two sets of activities involving different individuals or groups, although often using a similar set of approaches. An action research team is a core team made up of researchers and development practitioners. While they may share a set of overarching objectives related to the collaboration, their aims and responsibilities differ from those of institutional partners. The action research team is mutually responsible for the implementation of the PAR process and ultimately accountable for the outcomes and success of the project. Its composition will reflect the main aim of the project: a balance between development practitioners and researchers with teamwork abilities and who master a number of facilitation and analytical tools. A partnership, on the other hand, is an explicit agreement, written or not, that a team establishes with an individual, group or organization to whom a role has been recognized in the implementation of the project. The process of partnership building helps to define this role, as well as the conditions under which it will be implemented.

It must be noted that subsequent steps of the PAR process will contribute to team building and development of partnerships. Participatory action planning, for example, will help identify roles and responsibilities much more clearly and monitoring and evaluation will help to improve the performance of teams and partnerships.

Core processes

Core activities or processes within team and partnership building include:

1. Engaging individual team members and partners. The facilitator must take a lead role in calling others to the table, clarifying the aims of the partnership and consulting them on their interest in being engaged, but not impose his or her own interests or views. This helps to build trust, minimize suspicions by clarifying aims and clearing any doubts, and increases the chances that team members or partners will come to the table with a positive attitude.
2. Meetings and workshops, which are useful for:
   - Developing a common understanding of the background of team members (academic, working experience, level of knowledge of the PAR process, strengths and weaknesses) or partners (mandate, modes of working, what they can offer and would like to achieve through the PAR process);
   - Ensuring that people are at the same level of understanding of PAR, by conducting refresher meetings with the team and at community level;
   - Exploring differences in work style, which can help to transform points of misunderstanding into opportunities for building complementarities among diverse individuals (e.g. using personality tests);
   - Understanding the importance of working as a team, challenges that can be faced and approaches for dealing with challenges;
   - Agreeing on roles and responsibilities for team members/partners;
   - Holding brainstorming sessions on ways to facilitate change; and
   - Planning.
3. Regular feedback and reflection meetings to jointly evaluate progress relative to what was planned and distill lessons that can be used for moving forward.
4. Regular team/partner interactions, which may include:
   - Social gathering and outings to build team rapport; or
   - Joint activities in the field to build a common understanding of the PAR process as it unfolds.

Examples of successful team-building processes are shown in Boxes 1 and 2.

Box 1. Partnership building in the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe (N. Nemarundwe)

The CAMPFIRE programme is a community-based natural resource management programme initiated in Zimbabwe during the mid-1980s to facilitate long-term rural development through management of natural resources by local communities. Management of forests and wildlife had historically been the mandate of state organizations with little or no consultation of rural communities. CAMPFIRE aimed to facilitate active involvement of these communities in the management of natural resources in their locality. The initial focus was on the management of wildlife resources and was facilitated by the Department of National Parks and Wildlife Management (DNPWLM). With the realization that management of common pool natural resources requires a multi-disciplinary approach, various institutions came together to facilitate the implementation of the programme. These included the Worldwide Fund for Nature (WWF), the Centre for Applied Social Sciences (CASS) at the University of Zimbabwe, a rural development NGO called Zimbabwe Trust (ZIMTRUST), the CAMPFIRE Association (CA), and the Ministry of Local Government, Rural and Urban Development (MLGRUD). Given this involvement of multi-institutions with different agendas and expectations, there was need to ensure good coordination and strong partnerships amongst these organizations.

The first step was to identify the purpose of partnership building activities, which was to create platforms for collaboration and to identify roles and responsibilities for each organization (so as to ensure that there were no overlaps in roles that could cause conflict among the implementing partners and to identify areas of complementarity). The process of establishing partnerships involved:

1. Holding start-up meetings and workshop where the goal and objectives of CAMPFIRE were clearly outlined and agreed upon.
2. Defining roles and responsibilities of each organization, as follows:

DNPWLM – Ensure that statutory regulations relating to wildlife use are adhered to;
WWF –Provide advice and assistance to rural communities on ecology and wildlife management, and economic and financial management;
CASS – Socio-economic research; policy and institutional analysis (baseline surveys, monitoring impacts on rural communities);
ZIMTRUST –Assist communities and rural district councils in strengthening their management skills and developing local institutions for wildlife management;
CA – Lobbying and advocacy on behalf of communities; and
MLGRUD –Advise partners on local government policies and practices; audit and supervise district authorities involved in wildlife management.

3. Nominating an institution that would actively manage and coordinate programme activities (in this case, the CA).
4. Developing a strategy to facilitate continuous feedback among all partners, covering mechanisms such as seminars and policy roundtables to keep everyone up-to-date.
5. The feedback for a set the tone for a continuous process of adjusting roles and responsibilities as necessary, as well as bringing in new partners that are identified as relevant to addressing identified challenges.

Outcomes included a shared vision of what CAMPFIRE aimed to achieve and how the goal and objectives of the programme would be achieved; clearly defined roles and responsibilities of each partner; supportive working relationships among the partners; and complementary contributions from different areas of expertise, leading to CAMPFIRE being hailed internationally as a success.

Box 2. Partnership building in the CoFCCA project, CAR/DRC (CoFCCA Team)

Since CIFOR, as a research institute, does not have the expertise required to support the implementation of all the activities identified by beneficiary communities, certain technical responsibilities are entrusted to development partners. The first step is to draw up partnership agreements with the latter through negotiations on the nature of their involvement with the project managers and with the aforementioned communities.

In the Ndima Nzaso forest, Central African Republic, and in Mambasa and Kisangani in DRC, negotiations entailed the following steps:

Step 1 -

- Review of identified adaptation activities and strategies by community representatives;
- Selection of activities that can be carried out under the CoFCCA project, considering criteria such as :
  – Short- or medium-term feasibility
  – Compliance with project goals and the CIFOR mission (clear link with forests, peoples and adaptation to climate change)
  – Reasonable cost
  – Experimental nature
- Classification of identified activities into two categories: feasibility dependent on external aid, or not – the latter being planned without delay;
- For activities requiring external aid, identification of potential partners by community representatives.

Step 2 - Explanatory visit to identified partners.

Step 3 - Exploratory workshop with all the partners. During this workshop, each partner selected activities to support and the type of assistance, e.g. provide equipment, expertise, funding or proximate monitoring. The supporting partners came together to focus on given activities and decide on their scope (e.g. grow X number of hectares of cassava per village), the breakdown of roles (Who is to do what?), responsibilities (Who is responsible for the success of what?) and also to draw up an action plan (What? When? By whom? With whom? How?).

Step 4 - Each partner worked out the terms of the partnership agreement with the CofCCA project. This meant that each partner had to define the partnership goals, intended activities, expected outputs and impacts for the beneficiaries, implementation schedule, roles and responsibilities of each party, and the related budget. The preliminary terms of the agreement were then amended by each of the parties until a consensus was reached.

Mobilization

During and/or following the initial stages of team-building, the next stage generally involves contacting communities and other stakeholders. Often there are protocols that should be followed when entering a community for the first time, such as contacting local leadership to inform them of the aims of the project and seek permission to engage with community members. A process of community and stakeholder mobilization should then be initiated. This is a process through which participants in a PAR process become interested and get self-organized and motivated to work together toward a common goal. It is also a process through which marginalized members of a community are tactfully consulted and engaged in the change process. It must be noted that subsequent steps of the PAR process will contribute to mobilization and the definition of this common goal.

Primary aims

The primary aims of mobilization are:

- To engage larger numbers of people in the change process
- To take stock of the variability and complexity of the society or set of stakeholders, and find ways to consult and meaningfully engage marginalized groups within communities
- To foster "local" ownership of the PAR process, which in turn enhances sustainability
- To mobilise local resources (knowledge and experience, labor, materials or financial contributions) and sustain collective inputs
- To build trust
- To share information

For mobilization to be effective, it is important that there is transparency of aims, and equal opportunity for all stakeholders to participate and express their opinions. This does not mean that the entire community or all stakeholders must be present before starting to plan, but that all have been informed and given the opportunity. Mobilization often entails identification of local institutions or civil society actors who are respected by the community and considered effective in mobilizing them, given their established track record and trust engendered in them by others. It is important at the same time to ensure that politically, economically or socially marginalised groups are not left out of the process, which often requires active attempts to identify and engage them during the mobilization process.

Core processes

The dynamic nature of the mobilization process, which must be responsive to local social norms and responses, makes it difficult to summarize into a series of steps. Common elements to the mobilization process, however, include the following:

- Formal correspondence (often written) with administrative authorities in an area where the project wishes to operate, if outside organizations are new to the area, as a means to enhance buy-in, ensure the project's legitimacy or avoid future misunderstandings.
- Informal visits to the area—including to government authorities at diverse levels, organizations with current activities related to the topic, and people with knowledge of the area and of previous interventions, in order to:
  - Learn more about the history and context;
  - Identify any latent conflicts between different social groups or regarding the topic;
  - Present the project to potential participants or supporters; and/or
  - Solicit advice on how to best enter local communities or engage certain stakeholder groups.
- Informal visits to communities to inform people of the project and mobilize different social groups to attend a first meeting, through a combination of visits with local leadership (traditional and government authorities) and informal visits with social groups who may not attend unless otherwise encouraged (e.g. the youth, women, the very poor, marginalized ethnic groups).

- Community-wide or multi-stakeholder meeting to:
  - Raise people's awareness of the project, its objectives and expected approach;
  - Solicit their permission and interest to work with them, and clarify what their roles might be;
  - Mobilize their future inputs and involvement; and
  - Inform them about the next steps, and solicit advice and inputs.
- Introduce the idea of village or stakeholder representatives, jointly identify the qualities and behaviours of good representatives, and agree on the way in which these representatives would be selected (including use of established criteria) and monitored.
- Partnership building.

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Participatory action research: Understanding points and aims

It is important to start the PAR process by grounding the process conceptually: Where are we starting from and where are we headed? Assessing where we are starting from can be done using three tools: the context study, the diagnosis and the baseline study. Understanding where we are headed is done through facilitating stakeholders to conceptualize the change they would like to see. An important tool for this is visioning.

Context Study

Key aims

The context study presents a picture of the system, including collection of information on the past and present state of interactions among stakeholders, actors and their environment. This enables the orientation and adaptation of future management actions. It enables the external

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facilitator to get a better understanding of the complexity of the site or the system. It gives the internal facilitator an integrative view of all data and enables an improved understanding of the needs and problems to be solved. Equally important, by identifying existing conflicts or tense socio-political relations, it may play a key role in avoiding potentially volatile cultural and political stumbling blocks in the facilitation process.

The context study presents unquestionable advantages to the facilitator, some of which are:

- A clearer, broader and more integrated view of the entire situation in the site;
- Increased capacity to determine the focal parameters to follow;
- Increased capacity to establish the causal relations between apparently independent facts; and
- Identification and preliminary analysis of the focal problems.

Core processes

The methodology used for the context study will depend very much on the main objective of the PAR project. However, it involves identification and analysis of diverse parameters, including biophysical, socio-economic and political characteristics of the site or the system, with emphasis on aspects directly linked to the focus of the project.

The context study is extractive research, insofar as it is initiated and carried out by an external facilitator/researcher with the aim of having a better understanding of the situation of the site. Usually, traditional questionnaires, participatory mapping and other standard data collection protocols are used. Secondary data collection and literature reviews should form part of the context study. However, this method proves limited vis-à-vis the complexity of the situation met in the field, and alone is insufficient in giving the facilitator adequate understanding with which to adapt to unpredictable and complex situations.

The context study is best carried out in an interactive way, using tools borrowed from participatory methods or a set of criteria and indicators (C&I) as an investigation framework. The participatory context study informs external facilitators about the complexity of the site and protects against avoidable errors based on ignorance of the local context. It also allows local actors to gain access to outsiders' knowledge and provides an opportunity for developing a shared understanding of local concerns, issues and challenges of concern to different groups. This approach also offers an opportunity for the less powerful actors to participate in the identification and analysis of their problems/concerns and in the definition of activities to be carried out, thus helping to stimulate local ownership of interventions.

No option is exclusive and it is ultimately the combination of several factors, including the knowledge of the site or system, means available and priorities which determine the methods to adopt. Often, facilitators have difficulty in deciding the depth or the level of detail of the study at this stage. It is important to note that the optimal level of accuracy is a matter of common sense and practice. Too much detail may make this phase time consuming and inefficient, for most of the information collected is neither analyzed nor utilized in decision-making. On the other hand, it may be difficult with some groups to encourage them to go beyond very mundane issues to imagine a better future. At the end of this phase, the facilitator and actors together will have already constituted a set of potential problems to be addressed. It is important to sort out which of these falls in the line of the project and which ones will need to be tackled by partners.

Diagnosis

Key aims:

PAR is research oriented toward problem solving or overcoming obstacles to achieving a goal. The context study contributes significantly to the identification of the main issues to be solved or concerns to be managed. Yet solving a problem means combating its causes. The identification and analysis of factors which generated the problem or which contribute to sustaining it become a fundamental step towards the resolution or the mitigation of the problem. The participatory diagnosis can enable actors to identify the superficial and underlying, direct and indirect, proximate and remote causes of the identified problems (see Box 1). On the other hand, some approaches to diagnosis involve looking for alternative paths to reaching the goal (Mitroff 1997) or emphasize building on existing strengths in achieving collective goals (e.g. appreciative inquiry) instead of focusing only on the perceived problems.

The diagnosis or baseline constitutes an important step in PAR in the sense that it enables the production and consolidation of basic knowledge of the issue being addressed, as well as its socio-economic, institutional and ecological context. It facilitates the achievement of the following objectives:

1. To characterise the specific aspects of the issue being addressed by the project, and define the relevant project interventions. This characterisation will enable the definition of the complexity of the problem and identification of its key components, through which change can be better thought through.

Box 1: Preliminary and participatory diagnostic in the Boeny Region, Madagascar (ACCA Madagascar team)

A participatory diagnostic was carried out in Boeny in 2008 using local reflection groups (LRG) composed of some 20 farmers, together with local authorities. The goal was to bring out farmers' perceptions of climate change, identify the impacts these changes have had on the agricultural system, identify strategies currently employed to reduce vulnerability to climate-related disturbance and evaluate the effectiveness of these strategies. The 20-person LRG was divided into two groups by gender. A manual was provided to ensure that the discussion focused on pre-selected themes with questions such as: How do farmer perceive climate change? How are identified changes observed/affirmed? How do they measure the effects? What actions have been adopted in the past to reduce vulnerability to the effects of climate change? With what results?

A report-back session enabled a comparison to be made between the information produced by the two groups and to ensure a participatory process. The diagnostic showed that farmers clearly identify the following two major vagaries of climate:

- Progressively shorter rainy seasons, which since the 1970-1980 reference period have gradually declined from 6-7 months to 2-3 months;
- Overall increase in temperature.

Changes in rainfall have led to serious changes in rice cultivation schedules and in crop yields. Although three cropping seasons are still possible in this part of northwestern Madagascar, with vary asara (rainfed rice cultivation, from October – March), vary atriatry (rainfed rice cultivation with supplemental irrigation, February – July) and vary jeby (a flood-recession rice crop from February – June), ricefield productivity has declined by nearly 50%. Yet, in some irrigated areas, a fourth rice crop is grown — a fortunate outcome of the drop in rainfall.

Breaking down the results of this preliminary participatory diagnostic into social stakes and challenges inspired the construction of a collective vision.

2. To foster a common understanding of the issue and its causes, and initiate the process of awareness-raising and mobilization of local actors.
3. To select priority communities or groups from the population that the project will target. The identification of resource persons should also be included as one of the objectives of this step.

Core processes:

A good diagnosis is not easy to carry out; however, it is crucial for the success of a project. Very often the causes and the consequences are so closely intermingled that it is difficult to elucidate them. Actors are so entangled in their situation that they cannot easily solve problems on their own. Thus, facilitation by a third party can be instrumental. Facilitation of a participatory diagnosis requires both common sense and technical skills. There are several ways of doing diagnosis, and the choice should depend on the topic (e.g. climate change vulnerability). At the beginning of the process, it is important to identify an entry point so as to enable the discussion to start from somewhere. This might include an analysis of historical events experienced as a result of climate change, or changes in resources and livelihoods due to climate change. Another possible entry point is the discussion of a (possibly idealistic) vision of the future and of how climate related threats are obstacles to reaching that vision (see next section for details). If the resource and livelihood entry points have been selected, the steps in Table 1 can be followed.

Table 1. Example of steps in participatory diagnosis.

Step	Tools
1. Discuss the different aspects of climate change observed.	Brainstorming Historical trends analysis
2. Discuss the impact (directly or indirectly) of current climate related threats on resources, livelihood and activities (the positive and negative impact of climate change) as well as possible impact of future climate change.	- Brainstorming - Matrix (plotting climate change against activities and resources to discuss how each of the identified aspects of climate change affect different activities/resources) - Problem tree - Historical trends analysis
3. For each considered type of climate related threat, discuss the factors that make the certain social groups more vulnerable than others or that increase the negative consequences.	- Focus groups discussion Role plays - Analysis of local discourse, with feedback to the local communities
4. For each type of threat, discuss factors that help different social groups to cope.	- Focus groups discussion Role plays - Analysis of local discourse with feedback to local communities
5. How are the different groups responding to the different aspects of climate changes observed?	- Brainstorming Problem tree
6. Identify current and potential contributions of external actors in supporting local adaptive capacity and decreasing vulnerability.	- Focus group discussions - Visioning

For an example of an output from a diagnostic study, please see Box 2.

Conceptualizing Change

After characterizing climate change adaptation challenges and identifying possible interventions in a participatory manner (diagnosis), the team should have the requisite capacity to conceptualize change. This includes visioning and the definition of criteria and indicators that help to operationalize the vision by clarifying what concrete changes will be seen if the vision is achieved, even if only partially. This step enables collective definition of the project's general objectives with regard to changes participants would like to see brought about through PAR. In the case of climate change, this step should clarify how "improved adaptive capacity" is conceptualized by local stakeholders. After identifying the criteria and indicators for tracking change, it is important to carry out a baseline study to assess the condition of local indicators at the beginning of the change process. If a qualitative approach to baselines is chosen and participants still have energy following the visioning process, baselines can be established in the same meeting as the visioning exercise (please refer to the section on baselines for details). In some cases, the step of conceptualising change can be done jointly with the diagnosis.

Key aims:

The objectives of this step can be defined as follows:

1. To build consensus on the general orientation of change desired by all partners involved in the project.
2. To help develop a mutual understanding of alternative pathways through which the desired change can be achieved.
3. To support group reflection on possible actions that can help in realizing targeted changes.

Core processes:

Here, we will look at three tools: visioning, definition of boundary partners and the results chain.

1. Visioning

In visioning, there is always a risk that visions that are too broad, long-term or unrealistic are developed by participants and therefore of little use in planning. The facilitator must therefore consistently frame questions so as to focus on the topic at hand—namely, what a future will look like if people have learnt how to adapt to climate change. He or she can do this by making use of the output from the diagnostic phase to focus or narrow down the visioning exercise around key challenges or opportunities identified. Visioning also frequently requires explicit efforts to surface and aid in reconciling conflicts of interest, and often involves a lot of effort to negotiate different visions of the future by various stakeholders with divergent interests (see Box 2 for an example of how visioning has been used to resolve stakeholder conflicts). It can also help conflict to be avoided by facilitating the formulation of visions about the future in which complementarities or synergies among divergent sets of interests are identified. In this step, there is always a risk of ending up with a formula for change that is founded on a false consensus, obscuring points of difference that can ultimately undermine the project's success. Expert facilitation skills are therefore required to overcome this challenge.

The process of visioning change can be summarised in the following key steps:

1. Call together a village or stakeholder meeting in a common location. Break the group up into smaller groups based on the prior stakeholder analysis (carried out during the diagnostic phase), which should have surfaced different interest groups related to the challenges or opportunities associated with climate change. These local stakeholders

Box 2: Results of a diagnostic exercise by a men's group in Nkol Evodo Village, Cameroon (CoFCCA team)

In Nkol Evodo, a village in the humid tropical forest zone of Cameroon, an IDRC-funded project (COFCCA) carried out a participatory diagnostic activity related to the impact of climate change. A village workshop was called, and after an introduction to the purpose of the activity, men and women were divided into two groups to capture their respective views on the main problems faced. Men's productive activities included commercial and subsistence agriculture; hunting; fishing; collection ofnon-timber forest products (NTFPs) like palm wine, rope, rattan, casava leaves and fruits; and timber processing. Among these activities, three activities formed the main sources of livelihood: subsistence agriculture, NTFP harvesting and commericial agriculture. The men emphasized the following aspects of climate change:

- Drought during the rainy season and too much rain during the dry season
- Dry and cold wind which used to last 12 days now lasts for two months, the result being that the weather is now too cold and dry
- The dry season is now too hot
- Crop invasion by certain pests and weeds
- Violent wind that causes trees and their flowers to fall, affecting the production of fruit

The effects of climate change on men's activities were also identified using matrix ranking, as follows:

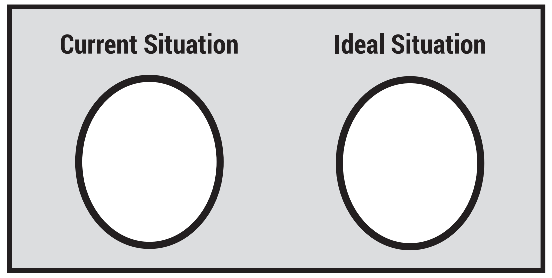
	Commercial Agriculture (Cocoa)	Subsistence Agriculture	Wetland Agriculture	NTFPs	Animal Husbandry
Change in the season	2	3	3	1	2
Dry and cold wind	1	1	1	1	3
Increase in temperature	+	2	1	1	3
Invasion by pests, weeds	2	2	3	–	–
Violent wind	1	2	3	2	1

Key: 1= Weak effect; 2 = Average effect; 3 = Very strong effect; + = Positive effect; — = Not relevant

Based on this diagnosis, the facilitator can help to facilitate a discussion on the way forward by asking how the positive impacts can be taken advantage of to improve livelihoods, and how the very negative.

groups may often have gender dimensions, but many times are strongly differentiated by their level of vulnerability, livelihood systems (e.g. farmers, herders) or their specific interests around climate change.

2. Ask the different groups to visualize their desiredfuture situations when the problems resulting from climate change (as identified in thediagnostic phase) have been solved. You can do this, for instance, byasking the following questions: "If you travel to the future, towards the end of the project and the project has had incredible success in solving the problems identified in the diagnostic phase: What do you see happening in your community? What do you see people doing differently from what they do now? How can you tell? What do you see people doing that is similar to what they are doing now? What has happened in terms of the well-being of different community members, and what changes have occurred to the various resources available in your community? The following simple tool, filled in with words or drawings, is a useful visualization tool for visioning:



During the diagnostic and visioning processes, the facilitator of each group discussion should actively take note of all the change variables or criteria mentioned in their interaction with the group they are facilitating. They need to carry these variables into the subsequent step, and actively check whether the interests of the interest group they facilitated have made their way into the shared vision that will be developed, and the associated action plans. Without this active role, the more powerful actors may dominate the planning process and the separate visions of the different interest groups can easily get lost.

3. Return to plenary, and ask the different groups to present their visions. After all visions are presented, facilitate a process for the larger group to come up with a jointly agreed vision. If there are clear incompatibilities in the different visions or they are completely different and cannot be merged, they need to be considered separately. After the visions have been merged, all the facilitators of the different groups in Step 2 must make sure that the interests expressed by their respective groups have been adequately captured or at least debated in the process of developing a vision.
4. Each of the facilitators from Step 2 should then present the change variables (or criteria) identified (Box 3) and ask the participants to comment on them and reconcile any that are at odds with one another. If it is recommended to eliminate some of these, the original proponents must be convinced of this decision before doing so.
5. Facilitate discussion on how the identified criteria will be operationalised, measured and tracked. The following questions may be useful for this purpose: "For [criterion X], how

Box 3. Weighting of criteria and indicators by various social groups (Tiani and Bonis Charancle, 2007)

The identification of simple criteria and indicators (C&I) was carried out by local facilitators with the support of external animators. Five focus groups were organized, each made up of about fifteen people from four large villages. They were: youth, women, Fulani (or Peulh), pygmies (Medjang) and local elites. In each focus group, tools such as word association and discourse analysis were used to develop a common understanding of sustainable forest management (SFM) and human well being (HWB) and build an ideal vision of the future. The method consists of enabling people to articulate their hopes, build awareness about their hopes and empower them to realize it is possible to achieve them (Wollenberg and Buck, 2000). These hopes are set as main objectives. The next step was to identify conditions to be fulfilled in order to reach these objectives. Conditions identified are criteria (and sometimes indicators). For each criterion, it is possible to elaborate one or a set of indicators and verifiers

1. Each social group was asked to distribute 100 points among the selected C&I. C&I were then ranked according to their cumulative weight, the most important C&I for the entire community being those with the highest total weight.

		Participating Focus Groups					
Rank	Criteria	Women	Elites	Youth	Medjang	Peulh	Total
1	Better access to health care	12	11	8	11	20	58
2	Social peace	6	15	12	15	13	53
3	Better children's schooling	9	10	10	10	6	43
4	To have a home and start a family	7	5	9	5	8	35
5	To have community forests to manage	5	10	5	10	1	35
6	Access to information	7	8	7	8	3	34
7	Better land use organization	7	5	3	5	9	33
8	Food self-sufficiency	8	4	4	4	10	31
9	Promotion of social and economic development	6	6	7	6	5	30
10	Rationale exploitation of forests	5	10	5	10	2	22
11	More solidarity within the community	5	3	11	3	4	27
12	Better community organization within CIG and associations	1	3	8	3	5	21
13	Unpolluted waterways	6	3	4	3	6	23
14	Soil fertility	9	2	3	2	1	23
15	Fishing and hunting regulations respected	4	5	4	5	2	20

Identifying indicators and verifiers is particularly important when C & I are to be used for monitoring purposes. This was not the case. So, we didn't emphasize this last step.

will you recognize that you are going in the right direction? What signs will show you that you have achieved what you set out to?" This is repeated until indicators are identified for all identified criteria.

From this point, you then move on to the participatory action planning process where stakeholders agree on the actions required to realize their visions and develop a plan for measuring performance towards this outcome—namely, measuring changes in identified indicators. This plan will specify the tools they will use to measure performance of different indicators, at what frequency and by whom. They will also identify what they can do, and what other actors should do, for enabling them to realize their vision. A baseline study should also be carried out to assess the status of the various indicators, as this is crucial for measuring impact later on.

It is important to realize that different social groups have different priorities. In some cases, the team may wish to ask the different groups to give weights to the different criteria (see Box 4). This will help to capture the priorities of different stakeholder groups, and to explore whether the change process is proving to be beneficial to different social actors. If it is discovered that this is not the case, these differentiated indicators become the basis upon which new actions aimed at meeting the needs of these social groups may be justified.

It is also important to note that generating a vision is a critical and often challenging task. While there is disagreement on whether the visioning process should identify visions that are realistic or expressions of the ideal, it is clear that one must move from the generic / ideal to the specific / real at some point in the visioning and planning process. Facilitating a process in which expressed visions are realistic is challenging. It can be done by careful questioning by the facilitator to probe deeper into past experience, and to verify whether emerging proposals are realistic and achievable. Alternatively, visions are left as expressions of the ideal and the identification of more concrete targets during the planning process used to support achievable plans of action.

2. Identification of "boundary partners" or partners you wish to influence

In some cases, such as when experimenting with new agricultural practices, the relationship between actions and expected changes is very simple. In other cases, such as when considering more complex adaptation strategies such as early warning systems or integrating climate change adaptation into local development plans, the change process is much more complex. In order for such strategies to reduce the vulnerability of the community or system under consideration or to increase its adaptive capacity, behavioral changes are required for a number of key persons or organizations. In order for the vision to become possible, participants in a PAR process must find ways to encourage them to take actions or change their behaviors

Box 4. The benefits of articulating specific variables or "criteria and indicator sets" to represent and track changes occurring in a system (adapted from Ritchie et al., 2000)

Identification of desirable change variables and indicators and verifiers that will help assess whether these have been met, has the following advantages:

- Enables participants to express what a concept related to an end goal (e.g. "sustainable management of resource X") means for to those involved in a change process
- Enables participants to assess performance against predefined targets
- Enables facilitators or participants to monitor impacts of management interventions and record change
- Provides guidelines for action towards the end goal through the identification of best practices
- Enables participants to adapt management strategies based on what is learned from the above process

and practices. These key persons or organizations that the group or project will interact with directly and seek to influence are called "boundary partners," a term borrowed from the Outcome Mapping approach (Earl et al., 2001). During the phase of conceptualizing change, it is important to understand the desired roles of these partners and how these can be manifested.

Identification of boundary partners can be done following the visioning exercise, in the same meeting. Once the vision has been defined and possible actions have been identified, the group can discuss: "Who else's help do we need? Who do we need to influence? What do we expect from them so that the vision can come true?" Through this exercise, the group might find that some of the identified partners brought into the PAR team rather than being seen as external partners.

3. The results chain

The results chain is a tool that is borrowed from "Results-Based Management" approaches. It is also part of the impact pathway approach (Douthwaite et al. 2007), which we re-visit in the section on Impact Assessment. It helps to conceptualise change by clarifying the relationship between inputs, activities, outputs, outcomes and impacts or the end goal. It can be adapted to local contexts by using appropriate vocabulary. Its use is especially justified in complex situations where influence over boundary partners is necessary to achieve the vision. In this case, changes in the behaviour, relationships and practices of boundary partners are some of the outcomes that must be articulated (among other intermediate stages which must be reached in order to achieve other types of impacts). Table 2 can be utilized as a tool for developing a results chain with stakeholders. The output column could be omitted in cases where the group does not plan to produce any intermediate product from the action.

Baselines

Key aims:

Baseline studies allow the starting point of a changing situation to be assessed using parameters relevant to the issue at hand. These parameters need to be observable, unambiguous, reliable and measurable. As mentioned above, baselines are identified for local indicators as well as indicators to be monitored by the project team. These indicators should reflect the vision, and usually describe biophysical and socio-economic conditions. In climate change adaptation projects, these indicators should be related to sources of vulnerability and/ or adaptive capacity. A baseline should also be established for key outcomes, i.e. key changes that are expected or desired from partners or other intermediate outcomes indicative of

Table 2. Questions that may be asked to aid in the development of a results chain.

Inputs	**Actions**	**Outputs**	**Outcomes** (including actors to be influenced)	**Vision / End Goal / Impacts**
Who participates? What resources?	What activities are required to achieve the vision or end goal?	What type of publication or other tangible product will be generated?	What early changes are we likely to see, should we be on the right track to achieve the vision/end goal? Who should we influence and what do we expect from them?	What is the ultimate aim of the activity?

progress toward impacts. In the following sections, we will use the word indicator to refer to both intermediate outcomes and impacts (e.g. conditions described in the vision).
The identification of these parameters is an important exercise which starts during the participatory visioning (where local indicators are identified), and continues through team-based planning exercises in which specific targets as well as gaps in local monitoring are identified. As mentioned above, these gaps could be due to the need to verify outcomes and impacts for a broader audience using more empirical research methods or to help explain a wider set of phenomena (either how these are affected by the change process, or instead constrain it). Project-based monitoring can also help to capture the effect of the project on a set of values of primary concern of the project or donors rather than local communities, such as equity or sustainability.

Core processes:

1. Participatory baselines
Once indicators are identified in the process of conceptualizing change, participatory baselines are carried out. This may be done qualitatively in the same meeting, or through field-based measurement (in some cases with the support of the research team, either to assist in research design or in data collection). Wherever possible, the community should be encouraged to identify local indicators that they can measure on their own.

Baselines for qualitative indicators may be established on a scale from 1 to 5, with 5 the maximum expression of a desired state and 1 the minimum expression or worst case scenario. At the baseline stage, participants are asked to discuss where they think they are at the present time. Different individuals will have a different perception due to their unique circumstances, and if possible different stakeholder groups should be encouraged to set their own baselines. Figure 1a illustrates a baseline based on 5 qualitative indicators, and Figure 1b illustrates the results of two subsequent participatory monitoring sessions (after key stages of implementation).

2. Project baselines
It is important to carefully consider indicators to be monitored, given the cost and time that must be invested in tracking the performance and evolution of these indicators over time and conducting final impact assessments. While some authors propose generic approaches to monitoring, for example to observe changes in the various forms of capital—social, physical,

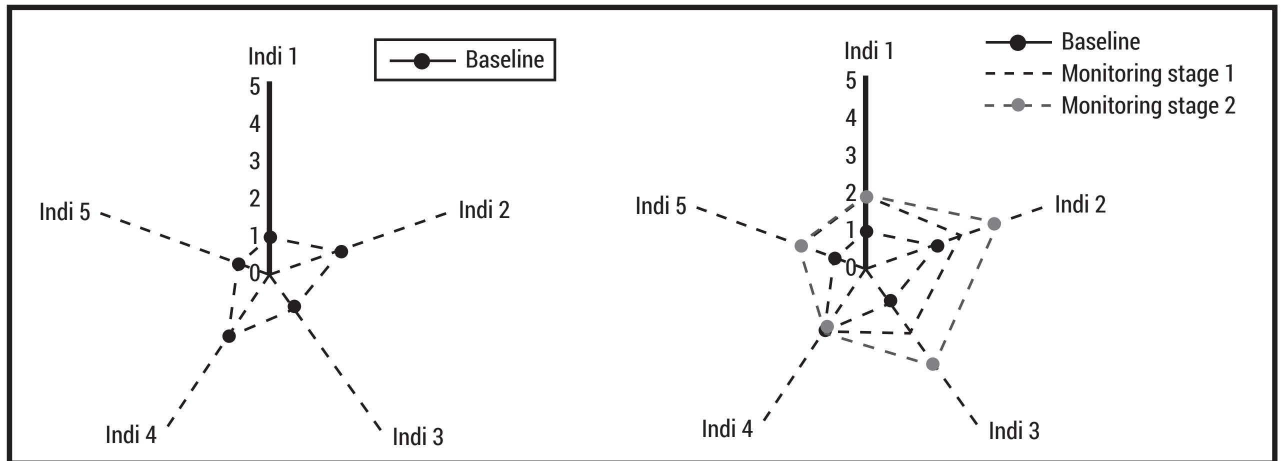


Figure 1. (a) Illustration of baseline for qualitative indicators, and (b) Results of participatory monitoring at key stages of the change process.

economic, human and natural (Endamana and Etoga 2006; Aldrich and Sayer 2007), we advocate an approach more focused on the specific problems to be solved. The way to achieve this is to conduct the baseline analysis following the steps of context analysis, participatory diagnosis and stakeholder visioning—when the scope of change is clearly identified.

The methodology for measuring the baseline situation of key indicators will depend on the specific indicator and standard norms of scientific rigor. For example, to measure the level of revenue from agriculture, standard household surveys instruments would be utilized. If measuring the baseline level of soil fertility, soil analyses would need to be conducted. If assessing the frequency of conflict, more qualitative methods may be required, such as identifying relevant indicators (e.g. of conflict prevalence, intensity or forms) through consultation of community members and finding ways to quantify these. For examples of participatory and project-based baselines, please refer to Boxes 5 and 6, respectively.

Box 5. Participatory baselines: The case of conflicts between local communities and loggers in Cameroon (A.M.Tiani)

In 2007, CIFOR was designated by WWF to manage conflicts associated with local opposition to forest concessionaires involving some 74,000 hectares. Being a site previously unknown to CIFOR facilitators, a multidisciplinary team was established to conduct a diagnostic survey of the area. A 5-day field trip was planned to establish contact with actors at various levels (concessionaires, administrative and traditional authorities, civil society and leaders of local associations), discuss the objectives of the project and to seek their support. A second field trip, of three weeks' duration, led to the characterization of the site through a context study. The site, made up of about fifty villages, was divided into 4 areas based on cultural identity, each one formed by many villages and surrounding hamlets. In each area, discussions were held by calling together focus groups of villagers and loggers, men and women, youth and adults, dominant ethnic groups and pygmy minorities – jointly and separately, according to the objectives. Various domains were explored:

- Socio-cultural context: Identification and analysis of stakeholders, resource access rules and land tenure, the structure of power and decision-making, and social capital in the form of collective action;
- Socio-economic context: Economic activities, economically important resources and their use, marketing, and socio-economic infrastructure;
- Socio-ecological context: Ecosystems dynamics and their causes; the spatial layout of resources and land uses; and the socio-cultural and economic importance of each ecosystem for different actors.

This context study was followed by a participatory diagnosis of conflicts, conducted through multistakeholder workshops in each area and analysis of findings among the facilitation team, as follows:

1. Identification of stakeholders and objects of conflict;
2. Listening exercise, giving the opportunity to each party to the conflict to formulate and express their grievances freely, and to propose solutions;
3. Discourse analysis following/during each event on reality of logging and how it affects each actor;
4. Identification of points of convergence and divergence among the actors in conflict, and key points for further negotiation;
5. Identification by each group of a set of criteria and indicators of good forest management;
6. Negotiation of perceptions and determination of a set of consensual criteria and indicators.

The baseline was then designed to understand the current status of negotiated criteria and indicators. This would later serve as the basis for later evaluating the project's success in fostering good forest management and, as a consequence, resolving conflicts.

Box 6: Project Baselines: Rangeland Degradation in the Algerian Steppe (A. Daoudi)

The CREAD / IDRC project in Algeria mentioned in prior case studies utilized project baselines to monitor changes in ecological indicators not selected by pastoralist communities, which would enable them to evaluate changes induced by PAR in objectives of interest to the research team and donors. As mentioned above, researchers identified two ultimate causes of rangeland degradation: vegetation removal and its effect on soil stabilization and biodiversity regeneration, and over-grazing. They chose a set of project indicators which included: vegetation recovery rate, levels of organic matter in litter, biodiversity in the soil seed bank and aboveground. Prior to initiating community action plans, scientists measured current levels of these variables in the various rangeland areas where the project was working and in "control sites" (rangeland areas where the project was not intending to carry out PAR). At this time, the team also agreed on plans for monitoring changes in these indicators over time. While such indicators could conceivably be identified by communities, more often they are identified by the research team based on the need to meet project objectives (e.g. supporting claims to impact, informing theory).

Planning

The stage of understanding the current situation and aims will have allowed a preliminary identification of possible actions to carry out and partners to influence in order to reach a desired vision. The planning stage involves developing detailed action plans and action research protocols from these preliminary steps.

Types of Planning

In action research, there are often two types or levels of planning: team-level action research planning and participatory action planning with local communities and other stakeholders. This is due to the slightly different aims (impact vs. research), elements and participants of the two processes. The two processes need to be conducted iteratively, due to the need to link local action plans and priorities to global research questions and audiences. While it may be debated which of the two comes first, we have found that an initial stage of action research planning is required prior to participatory action planning. This enables the articulation of the rationale for engaging in change processes (particularly for researchers), and global (common or widespread) challenges that we can best contribute understanding to. The second step is to identify global research questions and/or hypotheses to guide the change process. These are linked to an understanding of widespread challenges or opportunities and to theory and which must be adjusted based on the articulation of local stakeholder concerns. The result will be a generic framework (set of components or elements) for facilitating change that is grounded in theory. In the case of the CCAA Programme, this might include:

1. Articulating reasons for focusing on climate change adaptation, and foundational elements of adaptive capacity (local practices, service delivery, policy) that remain poorly understood and for which we can make the biggest contribution;
2. Developing research questions and hypotheses at the level of the CCAA Programme and in each funded project; and
3. A literature review to understand key challenges related to climate change adaptation, how existing bodies of theory inform change for each identified challenge, and to distill a set of "best bet" strategies most likely to enhance adaptive capacity.

Following this initial step of action research planning, participatory action planning is carried out. This involves a broadly inclusive planning process at the level of the community, landscape (involving multiple communities) or multi-stakeholder platform. It may also be followed by more in-depth planning around specific issues characterized by their complexity or by divergent interests that need to be reconciled. Participatory action planning is followed again by deeper development of action research protocols to link global questions with local priorities. While some components of action research planning remain fixed—for example, the background / rationale and research questions, others may evolve over time. For example, new hypotheses may emerge as learning progresses, and facilitation approaches planned in the beginning require adjustment to best respond to emerging challenges or opportunities. Efforts to articulate the linkage between the global research and the local change process are therefore ongoing, and iterative in nature.

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Source: The Application of Participatory Action Research to Climate Change Adaptation: A Reference Guide

By: Laura A. German, Anne-Marie Tiani, Ali Daoudi, Tendayi Mutimukuru Maravanyika, Edward Chuma, Nathalie Beaulieu, Henri Lo, Cyprian Jum, Nontokozo Nemarundwe, Edward Ontita, Giselle Yitamben and Victor Orindi
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Participatory Action Research: Empirical research inputs

Action research is not a substitute for conventional or empirical research. At different stages of the PAR process, it may be necessary to collect data using conventional research methods to inform the change process or more widespread sharing. Empirical research may be used in two primary ways—as an input to change, and to measure impact of the PAR process.

Empirical research as an input to change

Deeper analysis of the system can aid in system diagnosis and the identification of points of leverage for catalyzing change; informing decision-making by stakeholders involved in a change process; informing facilitation strategies of research teams; or supporting evidence-based policy making.

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Key aims

Empirical research can be instrumental for:

- Strategizing interventions most likely to work by identifying problems important to local residents, environmental "hot spots" (where on the landscape problems are most extreme), social conflicts, opportunities (i.e. local institutions respected by most parties) or other important guiding parameters
- Making variables visible to farmers, raising awareness and mobilizing their interest in finding solutions—for example through use of satellite imagery to illustrate landscape changes over time;
- Bolstering political commitment to a new approach—for example, impact assessments to illustrate the relative merits and demerits of different approaches to supporting local adaptive capacity;
- Providing data to mediate disputes, back evidence-based policy decisions or provide "policy targets" through an empirical understanding of a system;
- Empowering communities to question the actions of more powerful actors (Box 1);
- Monitoring change through use of scientific indicators to complement local indicators; or

Box 1. Scientific research can help inform policy-makers and legitimize local stakes vis-à-vis more powerful actors

During a participatory watershed diagnosis in Lushoto, Tanzania, farmers mentioned the incompatibility of Eucalyptus with adjacent farmland as a multi-stakeholder problem among neighboring landowners. One of the key stakeholders identified by farmers for boundary tree management was the Sakharani Mission, who planted eucalypts in 1970 to secure the farm boundary from encroachment. Since then, neighboring farmers have noticed negative effects of trees planted on both Mission and farm boundaries on their cropland and springs.

Since this problem can be partially addressed through policies regulating the location and density of Eucalyptus on or near farm boundaries, empirical research was undertaken to assess soil chemistry, soil moisture and maize yields near boundaries of Eucalyptus and other species perceived by farmers to be harmful to crops. Identification of significant negative impacts on crop yields or thresholds (specific distance from tree lines at which negative effects rapidly decline) would both be useful for guiding policy. While the former would provide a justification for a policy intervention in the form of restrictions on species or planting locations, the latter would provide a clear design principle for such interventions (i.e. species X not to be planted within Y meters of farm boundaries).

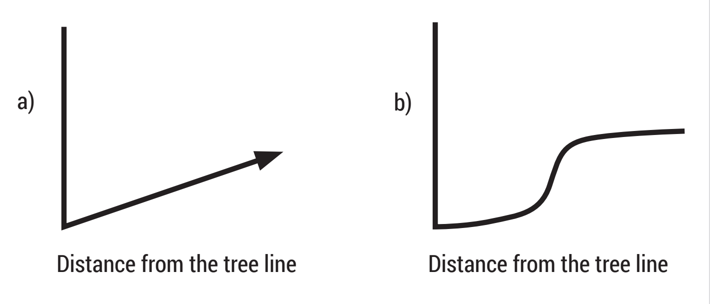


Figure U1. Hypothetical impact of boundary trees on the yield of adjacent crops in cases with (b) and without (a) thresholds.

While this was the theory behind the research, one farmer living next to the Sakharani Mission and "hosting" an empirical research experiment used the clear visual evidence of reduced yields near the Sakharani boundary to support his interests. He requested the District Forest Officer to visit his field, see the outcomes of the experiment, and demand for land use change by the Mission in the form of substitute species compatible with adjacent cropland. Clearly, such experiments can have both intended and unintended outcomes for livelihoods, learning and social justice.

- Systematizing local knowledge through social scientific methods in order to: (i) make highly specialized or localized knowledge available to a broader community; (ii) support multi-stakeholder negotiations either by identifying inconsistencies in the knowledge of different stakeholders (and the need to clarify causal processes), or by ensuring that common local understandings on cause and effect are actively integrated into decision making processes; (iii) identify "proven" solutions to similar problems embedded within local knowledge; or (iv) illustrate its utility vis-a-vis outsiders unaccustomed to the value of local knowledge.

It is important to note that while empirical research conducted during the diagnostic phase is often used to inform preliminary interventions, the timing of such knowledge inputs often cannot be anticipated. Challenges may emerge during the course of a change process that require more formalized knowledge or data collection techniques. Having flexible budget lines can enable research teams to be responsive to such emerging needs, in addition to being a fundamental component to an evolving, indeterminate change process.

Core processes

Core processes for empirical research involve standard data collection techniques for different social and natural science disciplines, as well as strategies to ensure that empirical research findings are utilized to inform ongoing change processes. The former may include any number of tools, from spatial analysis to botanical plots, soil chemical analyses, market chain analysis, household surveys, focus group discussions, and use of historical data to anticipate future trends. What is most critical is that any empirical research carried out be clearly linked to the PAR agenda and not just an academic exercise—particularly when involving communities who may become fatigued through high demands on their time in the absence of any concrete benefits. This may be done by giving involved stakeholders the opportunity to clarify "critical uncertainties" (unknowns that are otherwise crucial to decision-making), and by clearly thinking through how the information will be used to support decision-making by stakeholders involved in change processes or by policy-makers.

Impact Assessment

When a project has the objective of deriving lessons for a wider audience beyond the research site, the main purpose is often to illustrate that a particular approach to change works well and to distill lessons about what to do and not to do when seeking to enhance local adaptive capacity in the face of climate change. Yet how does a project substantiate claims to bringing impact or to enhancing adaptive capacity? Simply stating that an approach works will not provide sufficient justification to an audience considering applying lessons learnt or approaches as part of standard institutional practice. How does the approach perform relative to current institutional practice? What are the benefits, and at what cost to human and financial resources are they achieved? On what basis will your arguments gain credibility for this broader audience? The answer to these questions often lies in doing two things: (i) systematically documenting the change process, and monitoring how local and scientific indicators perform as the approach was adaptively managed and adjusted over time; and (ii) formal impact assessments to demonstrate impacts emanating from the change process.

Key aims

The primary aims of formal impact assessments are:

- To find out if objectives have been met and expected outcomes achieved, and identify factors which may have hindered full achievement of these outcomes;

- To be able to substantiate changes observed as a result of project interventions, and identify factors determining and inhibiting change;
- To systematically test hypotheses about "what works in practice" in terms of supporting adaptive capacity;
- To be able to assess the sustainability of outcomes and adaptive learning processes beyond the project cycle.

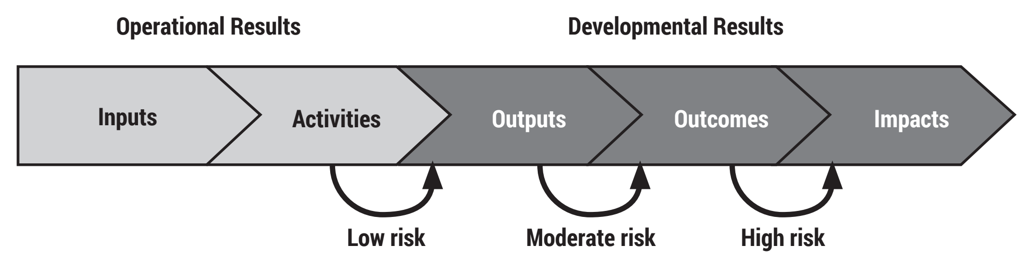
Core Processes

Impact assessments are designed following standards of academic rigor to:

1. Control "enumerator bias" (the influence the researcher may have on information provided by interviewees), for example by bringing in external enumerators;
2. Identify the right kinds of variables (unambiguous, measurable and relevant to the ultimate goals of the approach being tested);
3. Establish a "counterfactual", or evidence for what would have occurred in the absence of any intervention; and
4. Facilitate capture of both intended and unintended outcomes.

Enumerator bias can be controlled by ensuring that those collecting data about the project's impact are not project personnel, and by openly guaranteeing the confidentiality of information obtained from interviewees (so they feel more comfortable expressing themselves on sensitive topics). The rapport established between project personnel and the project's stakeholders may hinder the ability of project personnel to gather unbiased information about people's perceptions about the project, while confidentiality ensures them that their name will not be used in association with the information given—enabling them to speak freely. "Before" and "after" comparisons are important for assessing impact of project interventions, and involve comparing baseline data with data gathered following PAR interventions. Yet "attribution" remains a problem, as changes could have been induced by any number of intervening variables other than the PAR process. Counterfactuals are therefore necessary to determine which changes occurred as a direct result of the PAR process, and which occurred as a result of other contextual factors. They generally require a comparison of outcomes achieved "with" the project and "without" the project, for example comparing the situation within project villages and in non-participating villages.

Generally, articulation of an impact pathway (Figure 1) and being able to plausibly establish connections between different stages of that impact pathway (from inputs to activities, activities to outputs, and so on) is also required to understand the causal pathways through which changes occurred. Furthermore, it is increasingly recognized that impact assessments should focus on project "influence" rather than "impact", as multiple variables, actors and drivers often come to play in producing outcomes and impacts. The long time over which change often plays out—particularly in the case of adaptive capacity in the face of "slow" climate change variables—necessitates measurement of intermediate stages along the impact pathway or results chain (e.g. outputs and outcomes), which are defined during the stage of conceptualizing change. Outcome mapping is specifically designed to capture such intermediate stages of influence, such as attitude and behavioral change (Earl et al. 2001). Some adaptive collaborative management practitioners refer to such pathways as "plausible causal connections" (Colfer, pers. communication). The broader literature on impact assessment should be consulted when designing such studies, as this was not the subject of methodological innovation by the authors.



(Here, risk refers to the degree of likelihood that the changes associated with that stage of the impact pathway will not be achieved.)

Figure 1. Graphical representation of an Impact Pathway.

In the case of PAR applied to climate change, the main parameters or variables expected to change might include:

- The adaptive capacity of local actors, as evidenced by anticipatory and reactive efforts to prepare and respond to extreme events;
- More horizontal and vertical sharing of knowledge and information on climate change and adaptive strategies;
- The capacity of institutions to support adaptive capacity of local actors, as evidenced by the evolution of institutional mandates and policies; resources allocated to supporting adaptive capacity; and changing knowledge, attitudes and practices of policy makers and service providers; or
- Improved capacity of all stakeholders to learn from the past (e.g. actions or policies that have strengthened or undermined local adaptive capacity) and anticipate the medium-term consequences of today's decisions prior to taking action.

If "before and after" comparisons are made, baselines will be required against which subsequent changes are measured. As it is often difficult to predict the nature of changes that will occur through a PAR process, it is difficult to know which baseline data is most important. The tendency is to collect much more information than that which is actually useful, resulting in a tiring and overly "academic" process for local communities and other stakeholders. This problem can be ameliorated by using the visioning and planning processes of local stakeholders to identify the key parameters likely to change—and systematically measure these variables before initiating change (through participatory baselines or empirical research). Additional variables can be included based on researcher understanding of the broader system and how it constrains or enables change in the variables of interest to local stakeholders. Variables of importance to donors or the broader audience of action research outputs should also be considered, such as the impact on household incomes, and variables related to equity and environmental outcomes.

Some common variables in the case of climate change might include:

- Proxies to assess preparedness or adaptive capacity (for example, monitoring the performance of local indicators) see box 2;

Box 2. Example of a method to evaluate changes in adaptive capacity

Past climatic events will have affected different households or social groups differently, depending on their individual and collective adaptive capacities. The outcomes of past extreme events can be used as a means to reflect with stakeholders on factors that led to different outcomes for different households or groups (Why were some households or communities highly vulnerable, and others less so?). These factors known to lead to different outcomes become the variables used to operationalize adaptive capacity. They might include levels of household savings (financial capital or in the form of livestock and trees for ready sale in an emergency), the presence of protective infrastructure or social mechanisms for pulling together and sharing scarce resources in an emergency, or the effectiveness of government responses in different locations. These variables then become objects of change, while also being used to evaluate project outcomes by measuring them before and after PAR interventions.

Please note that these variables may be assessed irrespective of whether there is another extreme event during the project period.

- Ability to better predict climate variability, as evaluated by changes in institutional or local early warning systems or shifts in local knowledge and adaptive strategies;
- Frequency and quality of horizontal and vertical sharing of knowledge on climate change and adaptive strategies, as evidenced by the presence and frequency of use of communication strategies, the tendency to share local knowledge and adaptive strategies, and the perceived effectiveness of these strategies by diverse local groups;
- Evolution of institutional mandates and policies, as evidenced by institutional policies (Are they now more inclusive of climate change adaptation strategies?); shifts in resources allocated to supporting adaptive capacity; and the evolution of knowledge, attitudes and practices of policy makers and service providers (To what extent are government institutions responsive to local needs related to climate change vulnerability / adaptive capacity? To what extent are lessons learnt from the past (institutional memory) and from local communities incorporated into government policies and support strategies?); and
- The extent to which government institutions and local actors anticipate the medium-term consequences of today's decisions prior to taking action, as evidenced by concrete cases where this has been done during the PAR cycle and outside formally facilitated events.

Examples of specific methods and tools that may be used to evaluate impacts are summarized in Table 1.

Table 1. Examples of methods and tools that may be used for assessing impacts associated with adaptive capacity.

Aim	Method
Assessing achievement of stated PAR objective	• Participatory Monitoring and Evaluation including measuring the behavioral changes of boundary partners (e.g. Outcome Mapping) • Monitoring of project-based indicators related to local adaptive capacity and institutional change in support of local adaptive capacity in locations "with" and "without" PAR interventions
Assessing institutional change	• "Before and after" studies of institutional mandates, policies, knowledge/attitudes/practices, and budgetary allocations to supporting local adaptive capacity • Outcome Mapping by communities, other partners and project personnel to assess changes in attitudes and practices • Household surveys, focus group discussions (e.g. to evaluate changes in service provision)
Assessing local adaptive capacity	• Identification of local indicators related to adaptability during past stresses/extreme events (e.g. through historical timelines) and monitoring these using Participatory M&E Tools • " Before" and "after" comparisons of local knowledge and adaptive strategies and their effectiveness (using local indicators and/or empirical methods such as household surveys)

Source: The Application of Participatory Action Research to Climate Change Adaptation: A Reference Guide

By: Laura A. German, Anne-Marie Tiani, Ali Daoudi, Tendayi Mutimukuru Maravanyika, Edward Chuma, Nathalie Beaulieu, Henri Lo, Cyprian Jum, Nontokozo Nemarundwe, Edward Ontita, Giselle Yitamben and Victor Orindi
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Reference

Earl, S., F. Carden and T. Smutylo (2001) Outcome Mapping: Building Learning and Reflection into Development Programs. Ottawa: International Developing Research Centre (IDRC). 139p.

Ariel Lucerna 2015

Common challenges to participatory action research

It is important to recognize that PAR facilitators and action researchers will face challenges, even if the above steps have been closely followed. Creativity and peer support will be helpful in overcoming these and other challenges as they emerge. However, it is useful to be aware of a few of the most common challenges, and how these have been overcome in real life. This section was written for this purpose.

Motivating and sustaining interest

One of the most common challenges to PAR facilitators is motivating and sustaining interest of stakeholders involved in a change process. This includes motivating people to take action; sustaining interest over long periods or during prolonged diagnostic and planning phases; motivating partners while also managing their expectations so that more is not promised to them than what can actually be delivered; and institutionalizing the PAR or change process so that it can be sustained in the absence of project personnel.

This article was extracted from Section 6 of the book entitled *The Application of Participatory Action Research to Climate Change Adaptation: A Reference Guide* by Laura A. German, Anne-Marie Tiani, Ali Daoudi, Tendayi Mutimukuru Maravanyika, Edward Chuma, Nathalie Beaulieu, Henri Lo, Cyprian Jum, Nontokozo Nemarundwe, Edward Ontita, Giselle Yitamben and Victor Orindi, IDRC (2010). While many examples here are drawn from Africa but they serve as useful examples for Asian context as well. Refer to the source box towards the end of this article for a complete reference to the book.

Strategies that can be used for motivating and sustaining interest of actors involved in a change process include the following:

1. Ensuring a common vision with widespread buy-in. If all stakeholders have internalized and identify with the vision driving change, the likelihood that they will stay engaged is much higher.
2. Ensuring early successes. Stakeholders will be more likely to continue investing time and experimenting with new ways of achieving agreed objectives if they have been successful in achieving something collectively in the early stages of a PAR process. This means that the easiest targets that bring clear social benefits should be prioritized early on in a PAR process.
3. Combining short-term and long-term benefits. PAR processes aimed at tackling complex problems, particularly those that play out over the long run, will face the challenge of sustaining interest of stakeholders. It is therefore important to start with activities that are more likely to bring concrete benefits over the short and medium term.
4. Collectively defining rules for sharing responsibilities and benefits. This involves transparent negotiation and communication of what is expected of different stakeholders and how benefits will be shared. It is necessary for sustaining stakeholder interest in the PAR process. When such rules have been negotiated by the participants themselves, it helps to ensure that plans are realistic—namely, that benefits are sufficiently high to sustain people's investment of limited time and energy. It also helps ensure that expectations of them are communicated and realistic, and that there is fairness in decision-making. Rules should, however, be backed up by appropriate sanctions to discourage stakeholders from breaking the agreed rules.
5. Ensuring transparency and clear lines of communication among all stakeholders. All decisions should be openly negotiated and communicated, in order to generate a common understanding, minimise mistrust, and create opportunities to scrutinize decisions made by others.
6. Clearly communicating the importance of PAR activities to a wider audience beyond the pilot site. In cases where PAR is being conducted to learn lessons for a wider audience, it can be motivational for everyone to know that site-level experiences are contributing to the global knowledge base on how to address similar problems elsewhere. Sharing credit with partners and local communities during the dissemination stage can also go a long way in sustaining interest in PAR.
7. Having an "exit strategy." From the planning stage, the research team should be clear about its strategy for devolving facilitation and leadership roles—and the skills to execute these effectively—to local communities or other stakeholders involved in the change process. This will help ensure that the PAR process does not come to an abrupt end when the project ends or donor funds dry up (Box 1).

Power dynamics

Another common challenge faced by PAR facilitators is the complex web of power relations which shape patterns of participation, communication, decision-making, and ultimately benefits capture. There will always be actors that are more powerful than others, posing challenges to the facilitator and to other actors who may lose interest if their concerns are not taken into consideration. Power dynamics shape interactions between local communities and outside actors, as well as patterns of communication and participation within local communities themselves (Box 2). One of the more common challenges is keeping more powerful actors engaged in a change process, particularly if they anticipate few benefits or fear that their current position of privilege will be challenged. This is a problem of both

Box 1. Where to after withdrawal of external facilitation? (Adapted from Kozanayi, 2003)

This case study is about a three-year project in Chivi District, southern Zimbabwe, facilitated by a University department and partner government and non-governmental organisations. The project aimed to improve rural livelihoods by identifying, testing and promoting technical and other options for more efficient and equitable use of common property resources, within a micro-catchment area of about 4.5km² in size. Findings from context studies were used to identify entry points for the research project. High on the list of community needs was the desire to increase agricultural productivity in dryland crop fields through improved soil and water management practices.

A wide range of tools were used to facilitate various processes. The tools included:

- Farmer exchange visits for sharing ideas and experiences
- Leadership training as a way of generating internal drive
- Training for transformation to infuse a problem solving outlook
- Visioning and scenario building for defining development pathways
- Multi-stakeholder dialogue forums to reconcile diverse interests among stakeholders
- Use of demonstration and trial plots for soil and water improvement options
- Provision of technical and material support

External facilitation played a significant role and a number of projects were established in the village. These projects included soil and water conservation in both common property and individual plots; the expansion of an irrigated garden project; establishment of a micro-credit scheme; indigenous tree planting and management; and democratizing district by-laws through dialogue between district authorities and local communities. Considerable success appeared to have been achieved on these interventions during the presence of external facilitators.

As a result of increasing economic and political decline in the country, external facilitators withdrew prematurely from field sites. The various projects ran out of steam following the withdrawal of external support. A visit to the field site by one of the researchers two years after withdrawal of external facilitators revealed that most of the projects were no longer operational. The lack of an exit strategy and gradual hand-over of leadership contributed to the collapse of the various initiatives. In addition, introduction of material incentives (e.g. immediate rewards for participation in projects) in the early stages of the project may have given a false picture of active participation and success.

Withdrawal of such incentives translated into the withering of participation by local people. A lesson learned from this is that it is advisable not to introduce incentives up front, but later on as a result of participants' own initiatives, and to ensure an exit strategy is designed and put into effect at the planning stage.

Box 2. Elite capture of project benefits: The Okiek case in South-western Kenya (E. Ontita)

In a bid to protect forest resources from unsustainable uses, the Kenyan government has moved to resettle the remaining forest-dwellers to agricultural lands outside of protected areas. Since 1975, a resettlement project has worked to resettle the Okiek, a hunter-gatherer group residing in forests in the South-West Mau region. The land adjacent to the South-West Mau Forest is agro-ecologically high potential and much sought after by agriculturalists. More culturally savvy than the Okiek, these agriculturalists quickly learnt they could pose as Okiek and 'hijack' benefits of the resettlement scheme. Individuals from these other ethnic groups have managed to trick or manipulate government officials to settle them on land otherwise meant for the Okiek. With much of the land set aside for the Okiek running out, and many Okiek households remaining unsettled, they have remained in the forest – leading to the failure of the resettlement project. A more consultative process that explicitly sought to identify local stakeholder groups would have differentiated those with customary tenure over forest areas from other groups and avoided elite capture of project benefits. The Okiek case is an illustration of how projects can be used strategically by certain groups to further their interests – at times at the expense of other groups. Formal stakeholder analyses and more consultative development projects can help to overcome these challenges.

external actors and local elites. Another common challenge is the formation of new local elites that often occurs through external interventions or efforts to empower local actors. Yet power dynamics also play out within research and development teams, for example when contributions from junior team members are undervalued or they are given the most onerous tasks, or where certain disciplinary views are imposed at the expense of others. Good facilitators will be able to navigate through this web of influence to help level the playing field—empowering weaker actors to articulate their interests, or tactfully keeping more powerful actors from dominating.

A few strategies are particularly helpful in dealing with power dynamics. These include:

- Empowering weaker actors in parallel with efforts to secure elite involvement. Projects may incorporate explicit strategies to empower weaker actors to participate effectively in processes that affect them while not losing the participation of local or external elites whose involvement is necessary to effect change. Weaker actors often need activities tailored to their unique needs in overcoming barriers to their effective participation, while awareness creation among more powerful actors is often needed for them to recognize their interdependence with other stakeholders. Local or external elites can be given symbolic titles or roles to openly acknowledge their influence, while carefully ensuring they do not dominate key decision processes (as seen in Box 3). For example, local government actors can chair meetings, but facilitation roles for substantive tasks can be handled by the project team to ensure these more powerful actors do not have too much influence on the discussions and outcomes.

Box 3. Managing local elites when empowering historically marginalized groups (T. Maravanyika)

In Mafungautsi, one of the key ACM interventions was to empower marginalized groups (women, the poor, and those from minority ethnic groups) through various strategies such as training. With time, these individuals gained confidence and began to take a lead in meetings in which resource management issues were being discussed. After some time, the facilitators (the ACM team) realized that the local elites, initially active, had stopped coming to the meetings. The team devised a strategy for deal with this problem: acknowledging the elites openly for their crucial role in addressing the problem, and honoring them – for example, by asking them to give an opening address during meetings and resource management functions. This served as an incentive for them to continue taking an active role during meetings and activities, while also shifting roles toward greater empowerment of women, the poor and minority groups.

- Develop a comprehensive understanding of local and external stakeholder groups. Prior to initiating change, it is important to understand the diversity of actors within local communities and their interests vis-à-vis the envisioned change, so they can be systematically consulted at all stages of PAR (diagnosis, visioning, planning, monitoring). The same may be said for external stakeholders critical to the change process. Generally, a combination of formal stakeholder analysis and informal observation (only achieved through the project having a strong presence on the ground) is most effective in ensuring that all relevant groups are identified and their interests understood. Once identified, these groups are actively involved into the diagnostic and planning phases (for example, by ensuring each group is represented in decision fora and in monitoring) so as to understand how different groups are affected by the PAR process as it unfolds. During planning, negotiation support is often required to reconcile divergent interests (Box 4).

Box 4. Negotiation support to reconcile divergent views and identify opportunities for mutual gain: The case of the Sakharani Mission, Lushoto, Tanzania (L. German)

As mentioned above, during a participatory watershed diagnosis in Lushoto, Tanzania, farmers identified negative effects of boundary trees as a priority problem. As seen in earlier case studies, one of the key stakeholders identified by farmers for boundary tree management was the Sakharani Mission. In 1946, the mission bought land and established high-value trees and crops. Eucalyptus trees were planted in 1970 to secure the farm boundary from encroachment, and neighboring farmers had noticed negative effects of these trees on their cropland and springs. This was the main reason that multi-stakeholder negotiations were pursued between Sakharani and the three neighboring villages.

The first step following participatory watershed diagnosis consisted of visiting the Mission to convey the concerns of farmers to the Mission's farm manager. This visit was instrumental in moving multistakeholder negotiations forward in two ways. First, watershed problems had only been diagnosed in the minds of smallholder farmers, failing to capture the views of other land users like Sakharani.

These preliminary meetings were instrumental in highlighting concerns that the Mission had with regard to land use practices of neighboring households. These included the destruction of tree seedlings from free grazing livestock and decline in the Mission's water supply from upstream land use practices. Given the impartiality expressed by the facilitators for the concerns of the Mission in addition to those already expressed by neighboring farmers, the farm manager began to view the dialogue as an opportunity rather than a threat.

A second outcome of this preliminary stakeholder consultation was to enable the farm manager to make suggestions on how the multi-stakeholder engagement itself would be facilitated. The farm manager was asked to contribute his suggestions on the date and venue for the meeting and the agenda. Contributions to the meeting's agenda included the inclusion of local leaders from neighboring villages and efforts to de-polarize the concerns of each party. The latter led us to develop materials for initiating dialogue that emphasized the commonalities rather than the differences in the interests of each stakeholder.

While the first two concerns were the main reason for approaching the Mission, the new concerns raised by the Mission were also included as farmers' concerns. As these had been identified in the watershed exploration (but not in the context of community-Mission interactions), this was a fair representation of reality and the common concerns of both parties. By emphasizing shared concerns rather than polarized interests, the table helped set the stage for collaborative dialogue. The proposed meeting with other stakeholders was now seen as an opportunity by the farm manager to dialogue with his neighbors toward more optimal natural resource management for the benefit of both parties.

- Develop grassroots governance instruments to govern relationships within and among stakeholder groups. Once diverse stakeholder groups are identified and planning processes are underway, it is generally necessary to have clarity on how project resource and decisionmaking will be governed. This might include: (i) developing governance bodies or instruments; (ii) establishing "rules of the game" clarifying how decisions will be made, how responsibilities and benefits will be distributed within and between groups, and to ensure diverse groups comply with agreements (Box 5); (iii) building "soft skills" and awareness among weaker and stronger groups to level the playing field and foster mutual respect; (iv) providing negotiation support to proactively resolve tensions related to alternative visions and strategies for change and identify opportunities for mutual gain; (v) planning activities of particular interest to diverse groups, to accommodate diverse needs; or (vi) making equitable benefits the focus of all development efforts by drawing attention to who benefits or is disadvantaged by changes envisioned (during planning) or undertaken (during monitoring).
- Leadership training. One way of managing power relations and ensuring the sustainability of PAR processes catalyzed by outside actors is to build local leadership capacity on issues

Box 5. Governance bodies and "rules of the game": Key elements of grassroots governance in the Model Forest of Campo-Ma'an (A.M. Tiani)

The Campo-Ma'an Model Forest is a 70,000 hectare landscape bearing 60,000 inhabitants and represented by 7 Councils. It is governed by three structures, namely the General Assembly, a Coordination Committee and stakeholder platforms, and is regulated by a set of rules agreed, written and endorsed by members in the form of a document called a Statut. Twelve platforms were created in the Campo-Ma'an Model Forest. Each platform functions according to an internal set of rules called Règlement Interieur. The Coordination Committee provides a bridging function because it gathers representatives of all the platforms. Decisions are taken either at the level of platforms or Coordination Committees, depending on the level of their implementation or enforcement. A rural women's platform (PLAFFERCAM) led by a Presidente Generale, consists of 6 communal platforms, each one with about 20 to 30 women's associations. Each communal platform develops a set of activities of its own, but reports to the Presidente Generale, who is part the Coordination Committee.

related to representative governance and equity. Capacity building can move beyond one-off trainings to a "culture of change" by building observations on leadership and governance into monitoring and adjustment activities in ways that are not threatening. Strategies might include identification of characteristics of effective leadership at the planning stage, selecting leaders according to these criteria and monitoring their performance with them directly, or by focusing on areas of improvement rather than failures.

- Ensure PAR is focused not only on bringing change "out there" but also within teams. This may be done by: (i) using outcome mapping to plan performance targets for the team, and monitor performance during implementation; (ii) encouraging flexibility and experimentation in the facilitation / action research process itself; (iii) focusing on lessons learning not only on changes occurring "out there" but on the facilitation process itself (if PAR is facilitated by the project team); and (iv) formulating governance instruments or "rules of the game" at project team level, including decision-making processes (such as transparent planning and budgeting processes), behaviors (equal participation, sharing of arduous tasks, sharing of leadership roles and credit) or values (mutual respect).

Reference

Kozanayi,W. (2003) From Glory to Shambles: The Rise and Fall of the Romwe Initiatives. ACM Zimbabwe Newsletter. Harare: CIFOR.

Source: The Application of Participatory Action Research to Climate Change Adaptation: A Reference Guide

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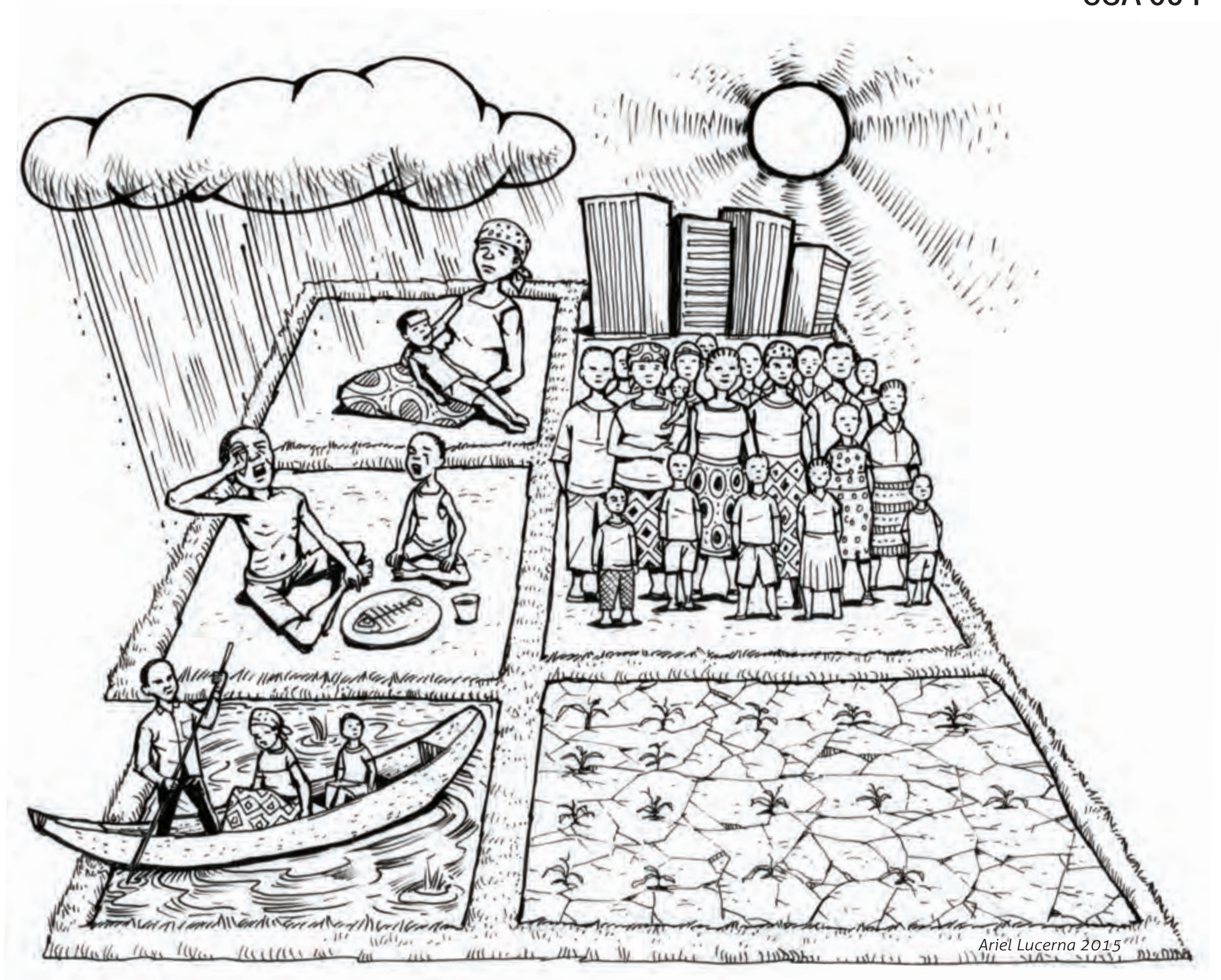


Community-based adaptation to climate change: An overview

Introduction

Scientists are clear that climate change is happening, and that it is due to emissions of greenhouse gases produced largely by industrialised countries (IPCC 2007). Those likely to be worst affected are the world's poorest countries, especially poor and marginalised communities within these countries. Ironically it is these poor countries and people who have contributed least to the problem of climate change, because of their very low greenhouse gas emissions, but who will suffer most from its consequences. Even if emissions are severely curbed, climate change will still occur. The industrialised countries have accepted they have a responsibility to help poor and vulnerable countries to adapt (UNFCCC). However, until recently, most adaptation efforts have been top-down, and little attention has been paid to communities' experiences of climate change and their efforts to cope with their changing environments.

This article was drawn from *Community-based adaptation to climate change: An overview* by Hannah Reid, Mozaharul Alam, Rachel Berger, Terry Cannon, Saleemul Huq and Angela Milligan. Refer to the source box towards the end of this article for a complete reference to the original article.

This special issue of Participatory Learning and Action focuses on recent approaches to adaptation to climate change which are community-based and participatory, building on the priorities, knowledge, and capacities of local people. Community-based adaptation draws on participatory approaches and methods developed in both disaster risk reduction (DRR) and community development work, as well as sectoral-specific approaches such as farmer participatory research (Berger et al. this issue) and Farmer Field Schools (Sherwood and Bentley this issue). Innovative participatory methods are also emerging to help communities analyse the causes and effects of climate change, to integrate scientific and community knowledge of climate change, and to plan adaptation measures.

In this overview paper to the issue, we describe how community-based approaches to climate change have emerged, and the similarities and differences between CBA and other participatory development and disaster risk reduction approaches. Whilst CBA is a relatively new field, some lessons and challenges are beginning to emerge, and we analyse these, drawing on the experiences contained in the collection of articles for this issue. Many of the articles are concerned with natural resources, reflecting the preponderance of submissions we received in this area. However, climate change will affect many other aspects of communities' lives, and we would urge practitioners working in other sectors, such as human health and urban areas, to share their experiences of community-based adaptation.

Climate change and its impacts

Climate change refers to short-, medium-, and long-term changes in weather patterns and temperature that are predicted to happen, or are already happening as a result of anthropogenic emissions of greenhouse gases such as carbon dioxide. These changes include a higher frequency of extreme weather events such as drought and floods, as well as greater unpredictability and variability in the seasons and in rainfall. Overlying this increased variability are expected longer-term changes, such as temperature and sea-level rises, and lower (or in some cases higher) rainfall.

Why are poor people most vulnerable to climate change?

Poor countries and communities are more vulnerable to climate change because they tend to be located in geographically vulnerable areas, such as flood-prone Mozambique, drought-prone Sudan, or cyclone-prone Bangladesh, and in more vulnerable locations. For example, the slums and informal settlements surrounding many developing country cities are usually sited on land prone to landslips or to flooding and river bank erosion. Wealthy people, commerce, and industry can afford to situate themselves on safer land.

Many poor communities are heavily dependent on natural resources for their livelihoods. Smallholder farmers have much experience of adapting to their complex, diverse, and risk-prone environments. However, farming is now becoming even more difficult and risky because of greater unpredictability in the timing of rainy seasons and the pattern of rain within seasons, making it more difficult to decide when to cultivate, sow, and harvest, and needing more resources to seize the right time for planting, and to maintain crops and animals through dry spells. Heat stress, lack of water at crucial times, and pests and diseases are serious problems that climate change appears to be exacerbating. These all interact with on-going pressures on land, soils, and water resources that would exist regardless of climate change (Jennings and McGrath 2009).

Vulnerability to climate change is not just a function of geography, or dependence on natural resources; it also has social, economic, and political dimensions which influence how climate change affects different groups (Action Aid 2005). Poor people rarely have insurance to cover loss of property due to storms or cyclones. They cannot pay for the healthcare required when climate change induced outbreaks of malaria and other diseases occur. They have few alterative livelihood options when their only cow drowns in a flood or drought kills their maize crop for the year—and they do not have the political clout to ask why their country's early warning system did not warn them of likely flooding. Climate change will also have psychological and cultural effects, for example beliefs and traditions associated with the seasons being undermined by climate change (Jenning and McCrath 2009).

Poor communities already struggle to cope with the existing challenges of poverty and climate shocks, but climate change could push many beyond their ability to cope or even survive. It is vital that these communities are helped to adapt.

Adapting to climate change

International climate change negotiations, multilateral and bilateral agencies, donors, and international governance and financial institutions such as the World Bank are paying increasing attention to adaptation and how best to help people to adapt. More and more funding is available for adaptation. However, until recently, most efforts to help countries adapt focused on national planning and top-down approaches based on climate change modelling. Remarkably little attention has been paid to the ways in which poor people have been coping with climate variability and extremes for decades.

What is community-based adaptation?

Community-based adaptation to climate change is a community-led process, based on communities' priorities, needs, knowledge, and capacities, which should empower people to plan for and cope with the impacts of climate change. As Tanner et al. and others in this issue point out, climate change is only one of a range of natural, social, and economic problems that may face poor people (such as unemployment, the prices of food and other essentials, commodity prices, drugs, gambling, community conflict, and health). So it is unlikely that interventions focusing only on climate-related risks will reflect community priorities.

CBA needs to start with communities' expressed needs and perceptions, and to have poverty reduction and livelihood benefits, as well as reducing vulnerability to climate change and disasters. In practice, CBA projects look very like 'development as usual' and it is difficult to distinguish the additional 'adaptation components'. For example, in a drought year, we cannot divide water storage measures undertaken by local communities into those initiated as a response to 'normal' climate variability, and those initiated as a response to climate change. However, the difference is that CBA work attempts to factor in the potential impact of climate change on livelihoods and vulnerability to disasters by using local and scientific knowledge of climate change and its likely effects.

CBA may start by identifying communities in poor countries that are most vulnerable to climate change, or these communities may themselves ask for assistance (Kelman et al., this issue). It may also follow on from work with communities to cope with a disaster, such as severe flooding. International development NGOs and donors funding CBA usually work through local partners, such as local NGOs or community groups which already have the trust of local communities.

Incorporating climate change information CBA work needs to incorporate information on climate change and its impacts into planning processes. This includes:

- scientific information (e.g. long-term predictions from climate change models, seasonal forecasts, information on trends based on data collected at nearby weather stations); as well as
- local knowledge about trends and changes experienced by communities at a local level and strategies these communities have used in the past to cope with similar shocks or gradual climatic changes.

Both these sources contribute to an understanding of risk. Climate change science cannot say for certain, for example, how much rainfall a particular area will receive over any given time—but it can give some guidance on the probability that rainfall will increase or decrease and to what extent. CBA builds in this notion of risk and uncertainty into activities, with the aim of building communities' resilience to both current climate variability and future climate change.

Drawing on participatory disaster risk reduction approaches

The lessons from disaster risk reduction (DRR) work are of tremendous value for climate change adaptation, because climate change is likely to change the magnitude, frequency, and timing of extreme events such as flooding, landslides, and storms, as well as generate new disaster events. Disaster risk reduction is likely to be the entry point for communities suffering from severe shocks as a result of short-term climate variability (Christian Aid 2009). Many of the papers in this issue use a participatory DRR framework (e.g. Tanner et al., Warrick, and Gaillard and Maceda). Although different approaches and frameworks for participatory DRR exist, all involve working with local people to understand the types of hazards they face (e.g. earthquakes, droughts, floods, pests and diseases, human diseases), the factors which make them vulnerable to these hazards, and their causes. These together give an indication of how 'at risk' communities are and which groups are most vulnerable. They also help communities consider what capacities they have for reducing vulnerability, and aim to empower communities to take action themselves to reduce the risks they face.

Many organisations working with local communities to reduce poverty and disaster risks are now trying to incorporate the effects of climate change into their work with communities. Kelman and Mercer (this issue), for example, describe a disaster risk reduction framework developed with communities to facilitate DRR planning in small island developing states (SIDS), such as Papua New Guinea. They then show how the framework can be adapted to take into account the likely effects of climate change by drawing on external scientific information such as downscaled climate projections and satellite images, as well as local knowledge of hazards and vulnerabilities. Taking into account these longer-term impacts is one of the key differences between DRR and climate change adaptation.

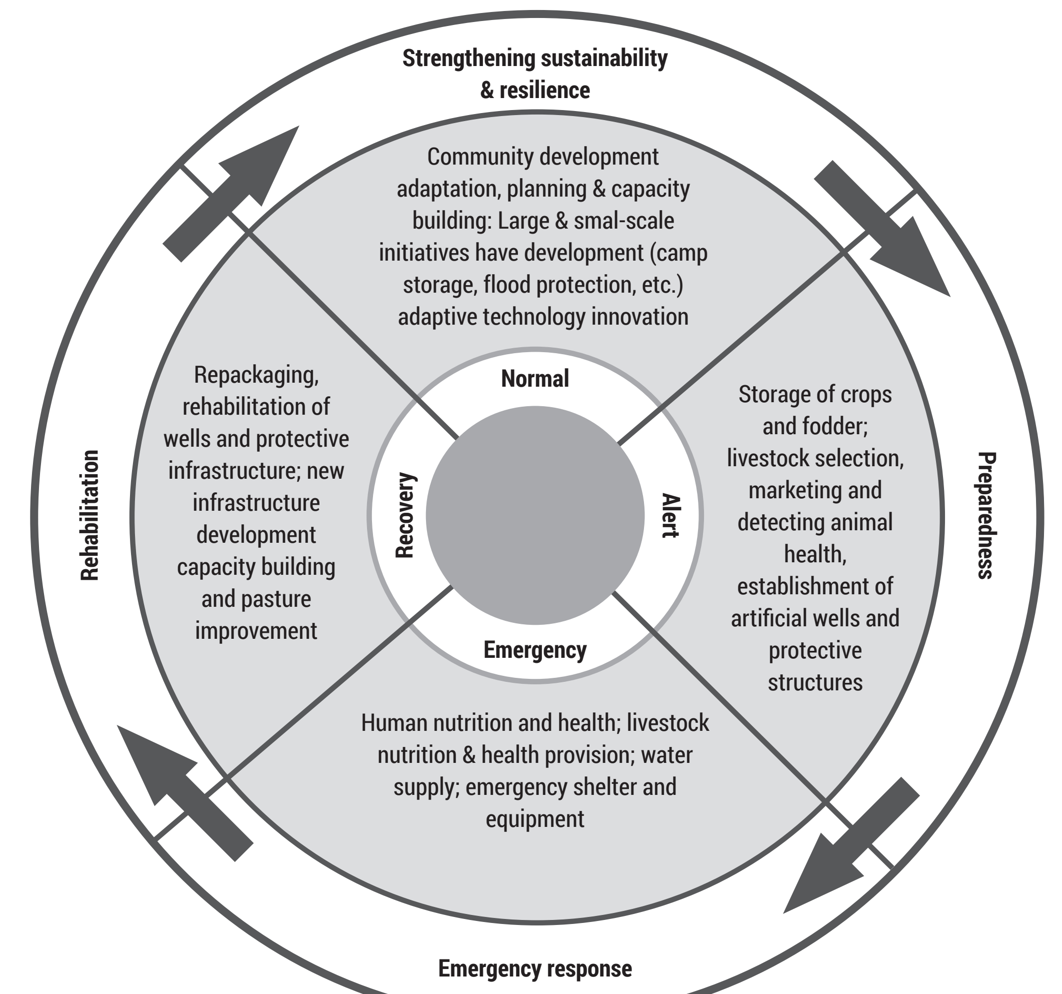
Livelihoods, DRR, and climate change

In practice, all disaster risk reduction and development work should take into account climate change impacts if development gains are to be sustained in the future. Whilst development agencies may differentiate between DRR, climate change adaptation, and poverty alleviation, at the household level the issues converge into one complex interrelated problem which boils

down to the same thing—the security and wellbeing of people's lives, livelihoods, and assets (Oxley 2009). There is increasing recognition that, for many communities facing frequent hazards, poverty, disasters, and climate change adaptation are closely linked and cannot be viewed in isolation from one another.

This points towards the need to find practical ways of integrating DRR, livelihoods, and climate change adaptation. Christian Aid, for example, has developed a climate risk cycle management approach to development planning which builds on the expertise and experience of existing DRR and livelihoods programmes, using existing tools wherever possible. In the model, predictable risks are anticipated, long- and short-term risk reduction activities are integrated into livelihood development, and the time spent in emergency or rehabilitation is minimised (Figure 1).

These integrated frameworks are still largely untested and there are likely to be challenges in handling the array of factors to be considered, as well as in encouraging the different support institutions needed to tackle vulnerability to work together. Participatory methods for CBA Many of the participatory tools used in CBA (see Table 1) will be familiar to DRR and development practitioners, but other innovative approaches are being developed for communities, development workers, and scientists to co-learn about climate change and adaptation, as well as for working with particular groups such as children (Tanner et al., this issue).



Source: Christian Aid (2009a)

Figure 1. Climate risk cycle management.

Table 1. Some examples of participatory tools used in CBA.

Participatory tool / approach	Uses
Mental models	• Drivers and effects of climate change
Seasonal calendars	• Seasonality and links with livelihoods • Can be combined with timelines to show perceived changesin seasonality over time
Timelines	• Hazards and events • Trends in climate, e.g. temperature and rainfall
Community mapping and modelling	• Resources • Types and causes of risks and threats • Extent of vulnerable areas • Vulnerable households and individuals • Planning DRRMC adaptation measures
Transect walks	• Vulnerablity / risks • Land use • Resources
Ranking	• Vulnerabilities and hazards • Coping and DRR strategies, e.g. water management options, crop varieties
Dream maps and drawings	• Vision of community or farm and how to achieve
Theatre, poems, songs	• Awareness raising of risks and risks reduction measures • Advocacy
Participatory video	• Awareness raising • Farmer to farmer communication • Advocacy
Stakeholder analysis	• Institutions, relationships, power
Key informant discussion (e.g. storian)	• In-depth discussion of vulnerability, livelihood sources

Co-learning about climate change

Whilst local people are extremely aware of changes in their environment, they often have little knowledge of the global causes and effects of climate change. The papers in this issue describe a wide variety of participatory tools to help communities understand climate change and the impacts it may have. Many use co-learning approaches, drawing on both local and external scientific knowledge. Communication about climate change should be in the first language of the community approached and in terms it can understand.

In Ghana, for example, communities developed mental models showing drivers and effects of climate change (Tschakert and Sagoe, this issue). During this process, they reinforced and expanded their own knowledge of climate change, with the input of external agents. In Indonesia, Climate Field Schools followed a participatory 'learning by doing' approach to help farmers increase their knowledge of climate change and observe climatic parameters themselves, such as rainfall, to help guide farming activities (Christian Aid, this issue). Sherwood and Bentley (this issue) describe a similar process in the Andes.

Children can be very effective communicators of climate change causes and effects. They often have a better understanding of the science of climate change processes than adults in the community, through school lessons, and can draw out the implications for local livelihoods. Plush (this issue) shows how videos, produced in a participatory way by children, can be a powerful means of raising awareness of climate change and its impacts, especially where literacy rates in the community are low. In this case, the children were first taught about climate change using locally available materials (although Plush notes that there is a severe lack of material that is not too technical, or related to the urban mitigation context). They then used this knowledge to develop questions and carry out filmed interviews with other community members, to give a clear picture of the impacts of climate change at the local level.

Although it is important for communities to understand the drivers and processes of climate change, Warrick (this issue) warns of the dangers of disempowering communities, giving them a sense that they cannot take action to deal with climate change, even though they have often been dealing with highly variable climates for many years. To avoid this, she suggests discussing climate change in the context of how people have already responded to climate stress, how this has changed over time, and on communities' own capacities to adapt.

Local knowledge about climate change

Several papers in this issue look at ways in which familiar participatory tools can be adapted to document local knowledge about climate changes. For example, rain calendars were used in Malawi to analyse changes in rainfall over the past five years (Awuor and Hammill, this issue) whilst seasonal analysis charts showed changes in the seasons in West Bengal, India over a similar timescale (Christian Aid, this issue). Climate timelines in Sudan were used to record extreme weather events and temperature trends over the past 30 years (Christian Aid, this issue).

In the absence of historical local weather data, the memories of older community members are often the only source of information on climate trends (Berger et al., this issue). Where scientific data are unlikely to be available, one way forward may be to strengthen local people's ability to collect their own data (Sherwood and Bentley, this issue).

Using scientific climate change data

The science of climate change and predictions regarding future changes have a key role to play in adapting to climate change. Finding ways of making scientific data accessible to communities is crucial if they are to adapt and remain in control of the CBA process. There are potentially many different kinds of information that would be useful for community planning, such as remote sensing observations, satellite pictures, downscaled climate scenarios, and seasonal and long-range weather forecasts. Where these are available, communities need to learn how to interpret them. Christian Aid (this issue), for example, describe how participatory climate forecast workshops were held in Zimbabwe, in which forecasts for the coming season, expressed in terms of probabilities rather than firm predictions. were explained to farmers, and then downscaled using farmers' own historical rainfall data.

Integrating local and scientific knowledge

Many of the papers in this issue consider how to integrate scientific and local knowledge so as to build on the strengths of each. Although this can present challenges, several papers suggest ways of bridging the gap between local communities and scientists (e.g. Gaillard and Maceda).

Identifying and planning adaptation activities

Participatory ways of documenting, prioritising, and sharing risk reduction and adaptation approaches are important if CBA is to fit with community priorities, and build on existing practices or those used in the past, for example traditional rice varieties which have better salinity tolerance than more recent varieties (Berger et al., this issue). Commonly mentioned on-farm adaptation options include diversification of the crops grown, changes in farming practices, better water management, and food storage. In extreme cases, for example, where droughts are likely to be of such magnitude that crops can no longer survive, then alternative livelihood strategies, or even migration may need to be explored.

There is much scope for approaches which encourage the sharing of adaptation practices. Sherwood and Bentley (this issue), for example, describe an approach to climate change adaptation in the Andes, in which farmers learn through visits to other farms and through experimentation. As farmers learn and take action at the farm level, the focus shifts to collective actions, such as sharing responsibility for collecting weather data, and implementing soil and water conservation measures.

Baumhardt (this issue) describes how farmers made videos of the adaptation activities they found most useful, which were then screened in nearby villages with which they did not have contact. Whilst the videos were an important communication tool for raising awareness of adaptation options, there are likely to be differences in abilities to adopt adaptation measures, and additional support will often be needed if local people are to make these changes.

Molina et al. (this issue) describe how children in the Philippines developed theatres, songs, and dances to communicate the potentially destructive impacts of hazards such as flooding and river bank erosion, and were effective advocates for risk reduction activities, such as tree planting.

Gaillard and Maceda (this issue) describe how communities in a flood-prone part of the Philippines created extraordinarily detailed, scaled three-dimensional models of their area, made from local materials such as cartons and paper, which they used for disaster risk reduction planning. They used the models to identify important areas for livelihoods, e.g. fishing and hunting grounds, areas prone to different types of flooding (river, tidal), different households, the material of their house (which affects how robust the houses are), household inhabitants, and the most vulnerable people in the community, e.g. young children, elderly people, pregnant women, and those with disabilities. They then identified local resources to deal with hazards, e.g. boats, vehicles, and then planned disaster risk reduction activities, e.g. meeting points, evacuation routes, and shelters. The information from these models can also be input into GIS systems for use by local government or scientists (subject to the communities' permission), and can easily be updated.

Lessons and challenges in community-based adaptation

Although CBA is a very recent development, a number of lessons and challenges are already emerging, around the availability and credibility of climate change information and data, the quality of participatory processes in CBA, scaling up, and monitoring and evaluation.

Issues around knowledge

Good information on which to base climate change adaptation is vital, but it is not always available, accessible, or credible.

Scientific data

Christian Aid (this issue) highlight the difficulties communities often experience in accessing climate change data that they can use in planning. Whilst climate models can help identify which parts of the world are more likely to be physically vulnerable, these predictions are often at a geographic resolution or timescale which are of little use to local communities. Better climate change models, which can make predictions that are more relevant for communities, are urgently needed.

There are also problems with weather forecasts. Meteorological stations are often woefully under-resourced and understaffed, data are not computerised, and data which would be useful for farmers are not collected. Jennings and McGrath (2009), for example, point out that the vast majority of analyses of meteorological records and climate model data focus on mean annual temperature and precipitation change rather than the timing of rains and intra-seasonal rainfall patterns, which are of much more interest to farmers.

Where data are available, communities are often not able to access them, for example, because they lack Internet access, or the data are not passed from meteorological departments to other government departments which can make use of them, such as agriculture. Finally, communities often have little confidence in the data.

Access to reliable, appropriate forecasts is essential in meeting the challenge of greater unpredictability and increased hazard events, and meteorological departments need to be strengthened to meet this need. Ideally, scientific data should be verified against local data, so that the scientific information has credibility with users (Christian Aid, this issue).

Local knowledge

Whilst communities often have little confidence in the reliability of information from scientists, scientists are often equally reluctant to trust local knowledge, which they regard as subjective and lacking in rigour (Gaillard and Maceda, this issue). However, in the absence of weather records and climate change data, CBA may be largely dependent on local knowledge of past climate trends for forecasting future trends.

Gill (1991) compared rainfall patterns recorded by Nepali farmers using rainfall calendars with the 'real' data recorded at the nearby weather station, and found a remarkably good fit when comparing modal rainfall. A more recent study was able to match farmer perceptions of changing timing and character of seasons against meteorological records and get a fit good enough to show that farmer analysis needs to be taken seriously (McGrath, pers. comm.). However, several authors (e.g. Warrick) note that, when analysing longer term trends with communities, more recent events tend to overshadow more distant ones, and this needs to be taken into account when trying to extrapolate from past trends.

Many communities use traditional systems to forecast the coming season. Sherwood and Bentley (this issue) describe how farmers use wind patterns, cloud formations, the position of rainbows, and animal behaviour to predict the coming season. Berger et al. (this issue) describes a traditional weather forecasting system called Litha, based on lunar cycles, and used by communities in southern coastal in Sri Lanka to predict rainfall patterns, and the best time to plant crops. However, there are fears that these traditional systems will become less effective as climate change impacts increase. Berger et al. observe that in recent years, the Litha system has been falling out of use, although whether this is because it is less effective or because scientific weather forecasts are more reliable is unclear, and this would merit further investigation.

Issues around participation

CBA activities demonstrate a variety of types and degrees of participation (see Table 2 for one typology). Participatory tools are sometimes used as a way of collecting local information about vulnerability and climate change to be used and analysed by outsiders (e.g. the case described by Wong, this issue). Often the priorities and interests of outsiders override those of communities, and there is still a lot of 'doing to' communities, rather than communities taking charge. Experience from many different fields, including those relevant to climate change adaptation, such as natural resource management and soil and water conservation, shows that if adaptation is to be effective and sustainable, it must draw on the knowledge and priorities of local people, build on their capacities, and empower them to make changes themselves. In this overview, we have argued that communities, scientists, and development workers need to learn, analyse, and plan action in partnership, but that communities need to be in the driving seat.

This has wide-reaching implications for professional behaviour, attitudes, and mindsets, and for institutional cultures and structures. Sherwood and Bentley (this issue), for example, point out that people-centred, community-based issues are in conflict with dominant professional behaviour and with dominant institutional designs. Outsiders are facilitators and co-learners, not 'teachers' or 'experts'. Participatory processes need time to develop and they need flexible funding. They do not fit with the pre-determined calendars, budgets, and outputs demanded by government and other organisations.

The way in which adaptation activities are funded may be of help here. Poor nations argue that, as wealthy nations have caused the problems of climate change, any international funding streams for adaptation activities should be used as recipient countries and communities see fit, and that such funding should be more stable and long-term than development funding, which is subject to the conditions and priorities of donors. This provides an opportunity for flexible, long-term funding of participatory community-based adaptation processes.

In the rush to go to scale to respond to climate change adaptation and to spend newly available funds, there is a danger that, as with PRA in the 1990s, participatory CBA approaches will be abused and misused. At the end of this issue, in 'Reflections on practical ethics for participatory community-based adaptation,' we have reproduced a statement by a group of practitioners called 'Sharing our concerns' (Absalom et al.), which was published in PLA (then PLA Notes) in 1994. This statement is essentially an ethical code for participatory practitioners, and with a few amendments, it has stood the test of time. We have also included here an extract from an article in a more recent issue, PLA 54 (Rambaldi et al. 2006) on practical ethics for participatory development practitioners.

Honest critical reflection—of the sort exemplified by Warrick (this issue)—is essential if CBA practitioners are to learn from each others' experiences. For example, what happens when, as Warrick cautions, climate change is not seen as a priority in communities, where a highly

Table 2. Types of participation

Type of participation	Characteristics
Passive participation	People participate by being told what is going to happen or has already happened. It is a unilateral announcement by an administration or project management without listening to people's response. The information being shared belongs only to external professionals.
Participation in information giving	People participate by answering questions posed by extractive researchers using questionaire surveys or similar approaches. People do not have the opportunity to influence proceedings as the findings of the research are neither shared nor checked for accuracy.
Participation by consultation	People participate by being consulted and external people listen to views. These external professionals define both problems and solutions, and may modify these in the light of people's responses. Such a consultative process does not concede any share in decision-making, and professionals are under no obligation to take on board people's views.
Participation for material incentives	People participate by providing resources, for example labour in return for food, cash, or other material incentives. Much on-farm research falls into this category as farmers provide the fields but are not involved in the experimentation or the process of learning. It is very common to see this called participation, yet people have no stake in prolonging activities when the incentives end.
Functional participation	People participate by forming groups to meet predetermined objectives related to the project which can involve the development or promotion of externally initiated social organization. Such involvement does not tend to be at early stages of project cycles or planning, but rather after major decisions have been made. These institutions tend to be dependent on external initiators and facilitators, but may become self-dependent.
Interactive participation	People participate in joint analysis which leads to action plans and the formation of new local institutions or the strengthening of existing ones. It tends to involve interdisciplinary methodologies that seek multiple perspectives and make use of systematic and structured learning process. These groups take control over local decisions and so people have a stake in maintaining structures or practices.
Self-mobilization	People participate by taking initiatives independent of external institutions to change systems. They develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Such self-initiated mobilization and collective action may or may not challenge existing inequitable distributions of wealth and power.

Table 2. A typology of participation[5]

variable climate is regarded as 'normal', or where climate change impacts are not yet evident, even though scientists are confident that there will be serious impacts? What happens when an external organisation's focus and funding does not match the priorities raised by communities? Without the flexibility to address communities' real concerns, it is difficult for the process of adaptation to be community-driven.

Difficulties with the concept of 'community'

Whilst CBA focuses on 'the community', it is very important to be aware of differences in priorities, needs, vulnerability, and capacities within communities. Tanner et al., for example, show that there are marked differences in perceptions of the importance of different hazards by age and gender in the Philippines. Men, as the farmers in these communities, highlighted agricultural hazards such as pests and drought, whilst women were concerned with social hazards (gambling, drugs), and children had the most awareness of environmentally unsound livelihood practices and global environmental problems.

Different sections of the community also vary in their capacity to undertake adaptation activities. Women are particularly badly affected by the combination of climatic and environmental stresses, but their particular needs and wishes for adaptation are less likely to be heard or acted upon (Jennings and McGrath, 2009) (see Box 1). Children are affected by both current and future climate change impacts, yet their voices are rarely heard or considered in climate change adaptation activities (Plush, this issue).

In many National Adaptation Programmes of Action (NAPAs), agriculture and forestry feature heavily as priority projects. However, McGrath and Jennings (2009) point out that, in Malawi, women prioritised a crèche, family planning, access to loans, credit, training, and free healthcare over support for agriculture. They argued that without childcare and support to start up small enterprises, they could not make adaptation changes.

Box 1: Looking within the community

Climate change impacts have different effects on women and on men and have been well attested in many places. The need to find water as well as firewood and fodder is a well-known reason for girls to be kept out of school, and male migration has been linked to the spread of HIV and AIDS. In Nepal, increasing crop failure has increased the strategy of men migrating. Women are left alone to look after families yet with the least access to resources to be able to adapt. They have less access to cultivable land to grow food and have to find water, wood, and fodder. Any worsening of livelihood options has to be made up in physical labour, one of the few resources women control. So to compensate for the decline in food production, women are doing more daily waged labour. This is often extremely onerous – such as portering construction materials – and badly paid – women are paid only three-quarters of what a man would earn for the same work.

Wong (this issue) highlights the dangers of ignoring intra-community power differentials when planning adaptation activities. Local chiefs ensured that their family members were included as community representatives, excluding the voices and interests of poorer farmers from decision-making processes. Even though the project made special efforts to ensure gender balance, planned adaptation activities were both poverty insensitive and served to reinforce existing power inequalities.

Many articles in this issue use participatory approaches in a differentiated way to capture the perspectives of different groups. Some make particular efforts to ensure that more vulnerable households, and vulnerable individuals within households, are included, for example, the participatory modelling process described by Gaillard and Maceda, giving the opportunity to ensure that the voices of those people are heard. Less is said, however, about analysing power relations within communities, and how differences in needs and priorities can be reconciled. ***We need to keep asking: Who benefits? Who loses? Who is empowered? Who is disempowered?***

Monitoring and evaluation

Monitoring and evaluation (MandE) of CBA activities will also be a challenge. Good CBA should be truly participatory and devolve much of the decision-making down to the community level, but this makes any centralised reporting or evaluation activities more difficult to coordinate. This is an important issue, because it is the responsibility of industrialised nations to help poor countries adapt to climate change, so some means of evaluating the effectiveness of funded CBA programmes is required. But any move towards centralised tracking and evaluating systems must be sure not to lose sight of the need to facilitate genuine participatory processes that empower communities to adapt to climate change in ways which address locally identified priorities.

Policies and institutions for CBA

Whilst CBA is focused on the community level, it cannot be carried out in isolation from events and activities occurring at other levels, for example:

- CBA is affected by the services and support available (or more often not available) at district and national levels, for example, long-range weather forecasts, downscaled climate scenarios, satellite images, information on weather forecasting, and agricultural and other extension services, and the ability of support organisations to integrate their activities.
- Some adaptation activities have spill-over effects on other communities, for example, if one community builds a dam to cope with drought, this will affect communities lower down the river. Wong (this issue), for example, describes how communities participated in transboundary river water governance in Burkina Faso and Ghana, which allowed for coordination and advance warning over the flow of water.
- Policy makers at district, national, and international levels need to know how communities are being affected by climate change, and to understand and respond to communities' priorities and needs. This might be through participation in 'invited' spaces, such as through participatory scenario development workshops (Bizikova et al. this issue), or through advocacy by communities (e.g. Plush describes how videos produced by children influenced policy makers in Nepal), or by communities organising and putting pressure on powerful local actors (Dodman, Mitlin, and Rayos, unpublished abstract).

Some CBA approaches explicitly build in a multi-level approach. Action Aid, for example, uses participatory vulnerability analysis (PVA), which starts by assessing vulnerability at the community level, but this feeds into the district, national, and international levels. They argue that there are multiple determinants/causes of vulnerability, and many of these fall outside individuals or communities. Hence analysis of vulnerability must go beyond the individual to micro- and macro-level political processes. Similarly, Practical Action have been developing a framework for understanding, analysing, and addressing the multiple factors—lack of resources; fragile livelihoods; hazards; climate change; political marginalisation; and, weak institutional support mechanisms—that contribute to vulnerability in an integrated and holistic manner (Pasteur 2009).

Conclusion

The theory and practice of CBA are still in their infancy. Both are likely to grow very rapidly, however, as needs increase as a result of intensifying climate change impacts and as interest in and support for adaptation grows at national and international levels.

Although funding is increasingly available for adaptation activities, simply providing poor country governments with more money does not mean that it will reach the poor and those who are most vulnerable to climate change, let alone increase their ability to adapt. Such communities are often marginalised, remote, and receive limited services and little support from their governments even when they are able to articulate what support they need. Reaching these hundreds of millions of people and supporting their genuine participation in any decision-making about resource allocation for CBA will be an immense challenge for any international or national programme or funding mechanism focusing on adaptation.

Whilst CBA initiatives are increasing in number and information sharing on these activities is developing, translating these activities and documentation into improved policy responses and scaled up CBA initiatives worldwide remains a challenge. Power structures are at the heart of climate change vulnerability and it is important to find ways to allow poor vulnerable people to influence policy and be heard in key policy arenas, such as the UNFCCC negotiations.

To be successful, community-based adaptation programmes will need to ensure that communities are able to participate in identifying priorities, both local and regional, and in planning, implementing, monitoring, and reviewing adaptation. Such programmes should provide support and link communities to relevant decision-making institutions. They will also need to build the capacity of local organisations and local governments to enable them to effectively take part in decision-making processes.

CBA draws on a number of different fields, including disaster relief work, community development work, and climate science. These different areas of knowledge and expertise often employ different languages and concepts, and there is still much work to be done in developing a common understanding and language, and sharing experiences and good practice.

Continuing to document CBA processes in an honest and critical way is very important, both to improve practice and to share experience in little-documented areas, such as incorporating climate change adaptation into health policy. You will find a list of resources on CBA, including websites, later in this issue. Other important opportunities for experience-sharing include the International Conferences on Community-Based Adaptation (see Box 2), and the two-day Development and Climate Days event, held each year during the Conference of Parties (COP) to the UNFCCC. This event has a dedicated CBA session to share information on CBA with negotiators and observers at the international climate change negotiations. CBA practitioners can also benefit from the rich literature that is available on participation.

Box 2: Sharing information on CBA

The second and third International Conferences on Community-Based Adaptation were held in Dhaka, Bangladesh, in February 2007 and February 2009. This will become an annual event at which practitioners, policy makers and researchers can share information on methodologies for CBA, upscaling CBA, communicating CBA, CBA in different ecosystems, funding for CBA etc. The next will be held in Dar es Salaam, Tanzania in February 2010. The conferences involve field visits to CBA projects in different ecosystems and regions so people can see CBA activities on the ground.

Final thoughts

We face increasing pressure to meet the myriad challenges that a changing climate presents. As this new community of practice emerges and matures, the ethics and quality of participatory processes will be central to the success of community-based adaptation to climate change — and there are both opportunities and dangers.

The opportunities are to initiate and sustain processes of change: empowering disadvantaged people and communities, transforming organisations, and reorienting individuals. The dangers come from demanding too much, in a top-down mode, too fast, with too little understanding of participatory development and its implications.

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The application of participatory action research to climate change adaptation

Climate change adaptation

Adaptation to climate change entails changes in processes, practices or structures, either autonomous or planned, to minimize potential damage or to take advantage of opportunities associated with climate change. Effective adaptation strategies should reduce present and future vulnerability and may include changes in institutional or individual practices in response to perceived changes, coping strategies, or proactive actions taken by various actors to capitalize on new opportunities (Huq and al. 2003; DFID 2004). Key concepts that will help to standardize language in the area of climate change adaptation include:

This article was extracted from the book entitled *The application of participatory action research to climate change adaptation in Africa: A Reference Guide* by Laura A. German, Anne-Marie Tiani, Ali Daoudi, Tendayi Mutimukuru Maravanyika, Edward Chuma, Cyprian Jum, Nontokozo Nemarundwe, Edward Ontita and Giselle Yitamben, IDRC (2012). Refer to the source box towards the end of this article for a complete reference to the book.

Adaptation: This consists of adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities.

Adaptive capacity: This is the ability of a system to adjust to change (including climate variability and extremes) to moderate potential damages, take advantage of opportunities, or cope with consequences. This capacity depends largely on one's access to assets (natural, human, social, physical and financial), and how well these assets are utilized. Those with higher adaptive capacity are often able to recover or adapt to new conditions. Greater adaptive capacity means the ability to cope with and/or reduce levels of exposure and sensitivity.

Vulnerability: This is the degree to which a system is susceptible to, or unable to cope with, adverse effects of change, including climate variability and extremes. It is understood as a function of exposure (the character, magnitude and rate of climate change and variation to which a system is exposed), sensitivity (structural factors that either heighten or lessen the impact of exposure, such as land tenure), and adaptive capacity.

Coping capacity: This refers to the means by which people or organizations use available resources and abilities to face adverse consequences that could lead to disaster. In general, it involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human-induced hazards.

Over the generations, African farmers have acquired detailed knowledge and skills that have enabled them to adapt to variable climate and extreme climatic events of the past. However, the more intense and frequent occurrence of extreme climatic events, together with population increase and mobility, is rendering some of these adaptive strategies inadequate. The high frequency of extreme events means that those impacted often do not have adequate time to recover and accumulate assets or resources for use during subsequent difficult times. There is hence a need to strengthen these strategies and support the development of better ways of managing the anticipated impacts of climate change. Vulnerability in Africa results from high levels of exposure (a highly variable climate), high sensitivity (from heavy reliance on rain-fed agriculture, limited access to information on climate predictions, lack of secure access to resources, and social disruptions of various cause6) and limited adaptive capacity. Adaptive capacity is in turn compromised by limited economic resources, low levels of technological and infrastructural development, erosion of local knowledge systems, limited incentives to invest in (long-term returns from) land, poor governance, and mismanagement of resources.

Adaptive management

Little is known about how and at which speed climate change will affect the various functions, goods, and services rendered by ecosystems, and how these, in turn, will influence human systems and adaptive capacity. The large number of political, social, economic, and ecological factors that individually or collectively influence climate change adaptation makes the management process full of uncertainty and complexity. Yet, despite lack of complete knowledge and information on these processes, decisions must be made on their management. The best approach, consequently, will be to prepare ourselves to live and deal with surprises and uncertainties by treating each management strategy as an experiment and an opportunity to learn. Dealing with novel situations therefore requires the capacity to learn and adapt, and to accept one's knowledge as partial. Peterson et al. (1997) argue that even climate change policy could benefit from taking an adaptive approach. Considering the uncertainty surrounding climate change, not only management systems but also policies that influence in some way—or are explicitly aimed at enhancing adaptive capacity—must be continually questioned and refined, based on learning.

Adaptive management is an approach for enhancing the capacity to learn and adapt by enabling managers to accommodate uncertainty and minimize risk and vulnerability. It is a process by which people adjust their strategies of management in order to anticipate or adapt to changes (Wollenberg et al. 2000). The approach is "based on the recognition that the management of natural resource is always experimental, that we can learn from implemented activities, and that natural resource management can be improved on the basis of what has been learned" (Borrini-Feyerabend et al. 2000). Adaptive management acknowledges that management of complex systems must take into account human dimensions and their interactions with natural systems (Lee 1993; see also Box 1). The linear or static management of such perpetually changing systems, as exemplified by the continuous application of a strict management plan, cannot enable the achievement of expected results. "Plans rarely work as originally conceived, and successful management requires regular feedback" (Colfer 2005:3). It is necessary to develop an iterative, adaptive model of natural resource management or change, capable of integrating in a conscious way the uncertainties and surprises that inevitably arise, and one that may be readily adjusted or renewed through learning and capitalizing on lessons. Adaptive management is recommended in situations that require that management actions be taken while knowledge on the impact of those actions is inadequate. PAR is a fundamental tool for enabling adaptive management in the context of climate change.

Box 1. Complexity of natural and human systems (A.M. Tiani)

Natural resource management is characterized by its extreme complexity, due to the diversity of natural and human systems. Thus, on the same space, the following could co-exist:

- A diversity of resources, goods, and services filling a multiplicity of social, cultural, economic, and ecological functions;
- A multiplicity of actors occupying various spheres and representing various interests, from local to global;
- Various objectives, interests, and motivations, sometimes contradictory (e.g., production and conservation);
- Different systems of rights and tenure that are overlapping, embedded, or mutually exclusive; and
- Power dynamics shaped by complex networks of alliances and ruptures between actors, and by constraints and opportunities often fashioned by unpredicted externalities.

This complexity means that attempts to control variables may often lead to unpredictable outcomes, requiring a more flexible approach to management.

Adaptive collaborative management (ACM) is an approach to adaptive management that explicitly acknowledges the partial nature of knowledge, be it the implicit knowledge applied by resource users in the management of complex socio-ecological systems or the explicit knowledge codified in disciplines and books. This implies reaching a shared understanding among stakeholders that everyone's knowledge base is only partial (including that of the more "educated" outsiders), that no one is able to predict outcomes with certainty, and thus that the group's actions are by definition experimental. It is therefore also important that the stakeholders who will directly bear the consequences of such experimentation are empowered to weigh the risks, and only take on those risks they are willing and able to bear. For more information on the ACM approach, see Colfer (2005), Kusumanto et al. (2005) McDougall et al. (2009) and Ruitenbeek and Cartier (2001). For more information about the relevance of ACM to climate change adaptation, see CIFOR (2008).

Participatory action research

Participatory action research (PAR) is a reflective process of progressive problem-solving led by individuals working with others to improve the way they address issues and solve problems. PAR is generally applied within social learning contexts, where multiple actors collectively construct meanings (problem definition, objectives) and work collectively toward solutions (Maarleveld and Dangbégnon 1999; Pretty and Buck 2002). Lewin, a pioneer of action research, describes the PAR process as "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action" (Lewin 1946; see also Figure 1). Iterative cycles of organizational or community-level action and reflection make change processes more robust and effective by ensuring that systematic learning and sharing take place, by fostering continuous adjustment of actions to align them with agreed-upon objectives, and by empowering the actors themselves to learn and adapt. PAR combines two primary activities: research and a facilitated process of social learning guided by a shared vision or set of goals to be achieved.

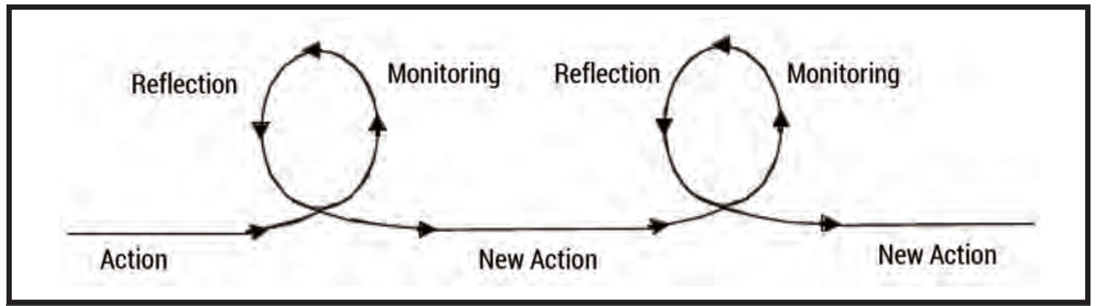

Figure 1. Graphical illustration of the iterative cycles of learning and doing in the PAR process

It is often assumed that PAR is a tool that is useful only for solving local-level problems and social issues. However, PAR may be carried out within research and development organizations as a process of institutional change, by policymakers who are interested in taking an adaptive approach to policy implementation, or by local communities as they seek solutions to common problems (German and Stroud 2007). It may also be used to enable biophysical solutions to work better by ensuring that diverse value systems are considered, and by facilitating an adaptive approach to change (Hagmann 1999; Hagmann and Chuma 2002). German and Stroud 2007 differentiate between participatory action research (PAR) and action research (AR). According to them, PAR is about "getting change to work," while AR is about "understanding the nature of change processes and distilling lessons of use to a wider audience striving to solve similar problems elsewhere." Whereas PAR aims to empower the actors themselves to identify key development bottlenecks and to experiment with different approaches for addressing and ultimately breaking through bottlenecks, AR enables a better understanding of the key elements to successful processes of development and social change (Ibid.). Differences between participatory action research, action research, and conventional research are summarized in Table 1.

This Reference Guide makes no such differentiation, as it combines the three "learning approaches" in the PAR process. However, it is useful to understand that the action research team has a set of unique roles relative to the other stakeholders involved in the change process as a result of its interest in distilling general lessons from specific change processes for a wider audience (the "research" in PAR). The uniqueness and complementarity of these different approaches will therefore remain apparent to many readers as they move through different sections of the guide. It will also be apparent in the way in which PAR and action research teams are discussed—namely, as distinct yet interdependent entities in the change process. For an illustration of how the research and the action are related to one another over time, see Figure 2. This separation of research from action should not be taken as something endorsed by the authors; it is simply a didactic means to illustrate the role of research within a PAR process. In practice, researchers should move seamlessly between their roles as participants in a change process (facilitation, empirical research, or partnership) and in more reflective, analytical work about the change process itself. The boundaries between these two

Table 1. Characteristics of different learning approaches (German and Stroud, 2007)

Characteristics	Participatory Action Research	Action Research	Conventional (Empirical) Research
1. Purpose	Solve localized problems	Derive lessons for the global community on how to solve certain types of problems	Characterize current or future situations and trends.
2. Tools	Interactive (facilitation, negotiation, participatory monitoring and evaluation)	Extractive (monitoring the performance of scientific indicators, impact assessment, process documentation) and interactive PAR methods.	Extractive (a large body of methods derived from diverse social and biophysical sciences)
3. Carried out by whom?	Actors in a charge process (farmers, leaders of organizational change, policy-makers, urban residents).	Researchers with an interest in 'process' (how transformationoccurs); change agents interested in deriving generalizable lessons.	Researchers: At times, change agents will also turn conventional research either for inputs (i.e. technologies) or to evaluate the impact of change process they facilitated.

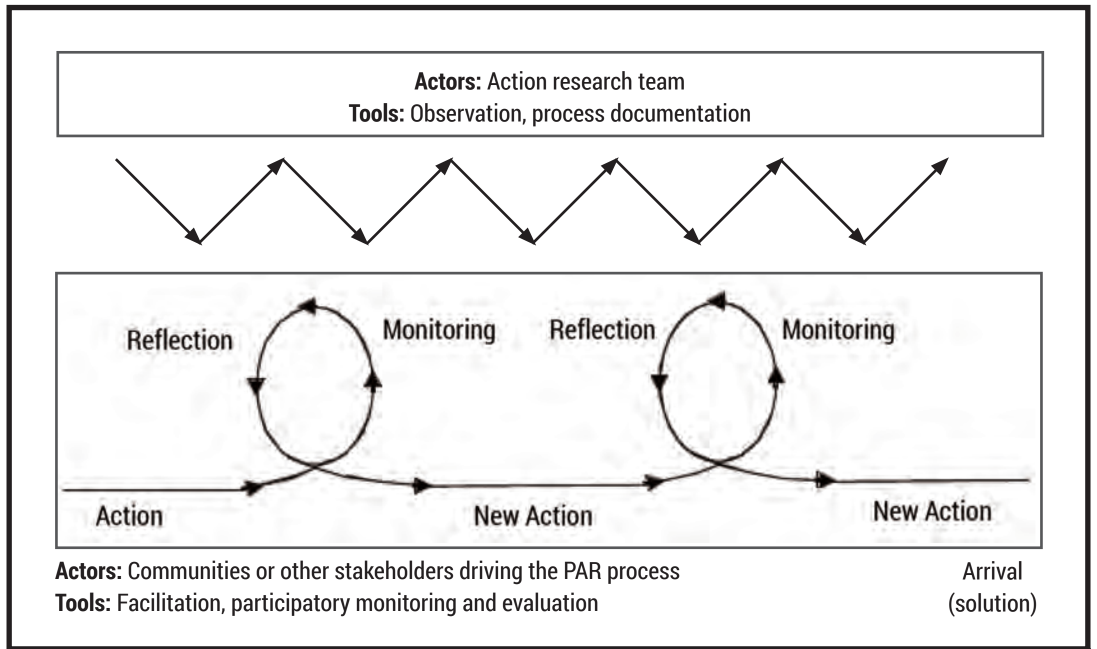

Figure 2. Illustration of the relationship between action research (upper box) and PAR (lower box).

"layers" are therefore fuzzy. One of the greatest challenges researchers face is to understand this "seamlessness" between research and action—and to move beyond the tendency to either lose themselves in "development" cycles or undermine the continuity or attention given to PAR by failing to drop their own research agendas.

In addition to differentiating PAR from action research, it is important to differentiate PAR from participatory rural appraisal (PRA) and from participatory research (PR). PRA is a set of analytical tools that enables villagers to do their own analysis of the realities that affect them, with a view to making use of such information. It is therefore not a comprehensive approach to enabling change, but may be employed within a change process to identify problems (for

Box 2. The question of validity in action research and PAR

Effort to put communities in control of the change process has created a certain discomfort among those in the long-established conventional or empirical research tradition. This has caused some to question the validity of action research and PAR. The questions often asked include, "How can one derive general lessons about change from happenings within a specific context, given the cultural, institutional, and ecological particularities of each setting?" "How can claims to validity be supported when there are no bearings to hold methods constant through time?" Some authors claim it is simply a matter of keeping one's "intellectual bearings in a changing situation" (Checkland and Holwell 1998:13). These authors suggest that claims to validity require a "recoverable research process based on prior declaration of the epistemology in terms of which findings count as knowledge will be expressed" (Checkland and Holwell 1998:9). In other words, one cannot engage in change without prior declaration of the scope of research and how it will be carried out. Elements of this process include prior declaration of an area of concern, a framework of ideas, and a methodology (Checkland 1991; Checkland and Holwell 1998). An area of concern is a topic around which the research is organized — in this case, processes or strategies for enhancing people's adaptability to climate change. The broader framework of ideas may include a conceptual understanding of the deficiencies of current practices, support services and policies on adaptation to climate change, and/or a set of guiding values (e.g. equity, sustainability) known to be deficient in current practice. It may also be a body of theory informing change (i.e. property rights and collective action theory, political ecology, ecosystem theory). As the effectiveness of change is largely determined by the actors themselves, the above authors would probably be comfortable with locally established aims and participatory evaluations of the change process as evidence of its effectiveness. Researchers with a more conventional approach to scientific validity may require research questions and hypotheses to be clearly stated up front and held constant, lessons to be derived from cross-site or cross-case comparison (within one or more sites), and conventional research to validate claims of effectiveness of the change process.

example, participatory mapping as a tool for participatory diagnosis of degradation "hotspots"), to establish baselines, or to identify constraints and opportunities (for example, periods within annual labour calendars when there is room for accommodating more labour-intensive activities). Participatory research, on the other hand, is research that is conducted as an equal partnership between external "experts" (generally, scientists) and members of a community. For research to qualify as participatory, it should be characterized by a reciprocal appreciation of each partner's knowledge and skills at each stage of the project, and research outcomes should be useful to the community. In this respect, PAR could be considered one form of participatory research. However, PAR tends to be much broader than participatory research in its iterative nature and, therefore, in its ability to enable more far-reaching change (social or system-wide transformation, rather than just the testing of technologies). Furthermore, failure to ensure local ownership of the process, and to place the nexus of power and decision-making squarely in the hands of the intended beneficiaries, subjects it to abuse.

At its best, the process can be liberating, empowering and educative, a collegial relationship that brings local communities into the policy debate, validating their knowledge. At its worst, it can degenerate into a process of co-option of local communities into an external agenda, or an exploitative series of empty rituals, imposing fresh burdens on the community's time and energy and serving primarily to legitimize the credentials of the implementing agency as 'grassroots oriented'.

This challenge and the abuses it gives rise to led, earlier on, to attempts to classify participatory research into different forms (Biggs 1989).

Figure 3 depicts the inherent tension that tends to exist in participatory research between science quality on the one hand and improved development on the other—a tension that more often than not tends to result in contractual and consultative modes of research.

In PAR, the same tension exists, but efforts to put communities squarely in control of the process mean that the process tends to lead to an emphasis on development impact over research per se. The challenge is always there for researchers to ensure rigour in the learning process and distill findings or lessons of wider relevance (Box 2)—and thus leverage the potential of PAR in informing wider communities of practice.

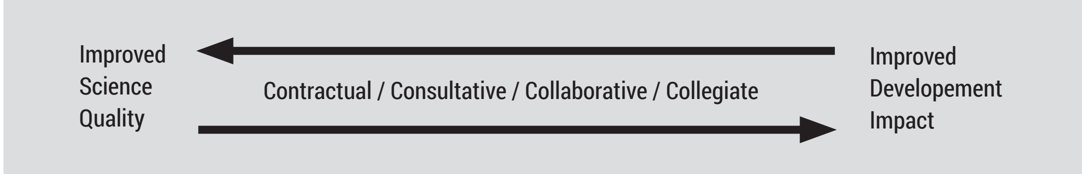

Figure 3. Different types of participatory research (Biggs, 1989).

PAR for climate change adaptation

The successful application of PAR in the past to solve problems in complex socio-ecological systems (Colfer 2005; Hagmann and Chuma 2002) and to facilitate institutional change (Elliot 1991; Hagmann 1999) makes many of the lessons and approaches readily applicable to climate change adaptation. However, it is important to also distill the features of PAR that make it uniquely suitable and those that limit its applicability to climate change adaptation. Key features of climate change and adaptation likely to shape the application of PAR include these:

- Climate change is a slow variable, with changes playing over the medium to long term;
- "Adaptive capacity" can best be assessed over long time scales;
- The predictability of climatic change is limited;
- Local and scientific knowledge10 on climate change and its impacts are inaccurate and/or incomplete;
- Nested levels of socio-political organization and response influence sensitivity and adaptive capacity; and
- There is a complexity (of climate change impacts, solutions).

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Source: The application of participatory action research to climate change adaptation in Africa
2012
IDRC

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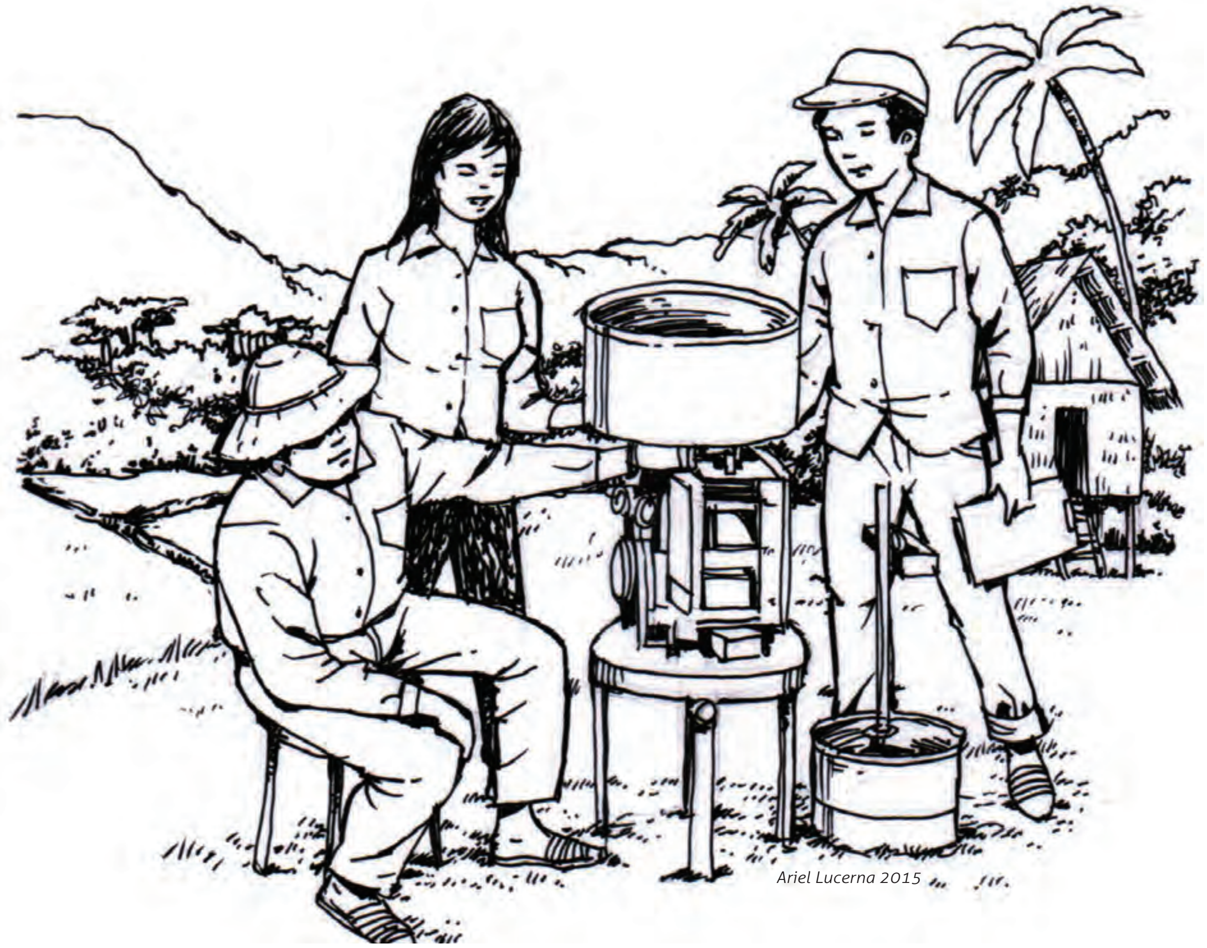

Climate services for farmers

Climate services are receiving increasing attention globally as an important component of the agenda on climate adaptation (Zillman 2009; Hansen et al. 2014). Effective climate information and advisory services offer great potential to inform farmer decision-making in the face of increasing uncertainty, improve management of climate-related agricultural risk, and help farmers adapt to change. Mounting evidence on the added value of climate services in support of improved decision-making in a range of climate-vulnerable sectors, including agriculture and food security, disaster management, health and water management, has played an important role in making the case for climate services (see Hansen et al. 2011; Tall et al. 2012; Hellmuth et al. 2007 for examples).

"Climate services" as we use it, encompass the provision of relevant weather and climate information, and a range of advisory services to enable decision-makers to understand and act on the information—within a suitable enabling institutional environment. Tall 2013 distinguishes between climate information and a climate service. A climate service requires

This article was repackaged from the original article entitled *Scaling up climate services for farmers: Mission possible - Learning from good practice in Africa and South Asia* by Arame Tall, James Hansen, Alexa Jay, Bruce Campbell, James Kinyangi, Pramod Aggarwal and Robert Zougmoré. Refer to the source box towards the end of this article for a complete reference to the original article.

appropriate and sustained engagement with users to understand their needs, to involve them in co-design and co-evaluation of information products and services, and to develop effective communication mechanisms. Most of all, a climate service needs to be responsive to end-user needs. While "weather" and "climate" represent distinct timescales, our use of "climate services" incorporates and expands on established weather information services that target agriculture. The atmosphere varies on a continuum of timescales, from sub-daily weather events to long-term climate change. These timescales of variability are often defined in terms of the dominant factors that drive them, and by extension, the source of predictability (table 1). "Weather" refers to environmental conditions at a given time, and is predictable at a maximum lead time of about two weeks. "Climate variability", on year-to-year to decadal timescales, is influenced by interactions between the atmosphere and its underlying ocean surface, such as those associated with the El Niño/Southern Oscillation (ENSO) in the tropical Pacific. At the long-term extreme of the continuum is "climate change" associated with natural and anthropogenic changes in the chemical composition and heat balance of the global atmosphere.

Climate-sensitive agricultural decisions also have a range of time horizons (table 2; Meinke and Stone 2005). Farmers typically need a combination of historic observations, monitored information through the growing season, and predictions at a range of timescales. To be useful, the timescale of information should match the planning horizon of particular management decisions. Relevant timescales for farm decision-making range from daily weather forecasts, to seasonal prediction, to climate change; but seldom exceed two decades. The field of agrometeorology has a long track record of research and applied work on delivering information and management advisories to farmers, based on monitoring and forecasting at the weather timescale (Stigter et al. 2013).

Table 1. Timescales of atmospheric prediction

Term	Timescale	Source of predictability	Treatment of uncertainty
Weather	< 2 weeks	Initial atmospheric conditions	Deterministic: hourly-daily weather sequences
Climate Variability	2 weeks to about 2 decades	Boundary conditions (ocean and land surfaces)	Probabilistic: shifts in probability distribution of seasonal statistics
Climate Change	> about 2 decades	Anthropogenic and natural changes in atmospheric composition and heat balance	Scenarios: projections of plausible future climate statistics with unknown uncertainty

Table 2. Climate-sensitive agricultural decisions at a range of temporal and spatial scales (Meinke and Stone 2005)

Agricultural decision	Frequency (years)
Scheduling (e.g . planting, harvest operations)	Intraseasonal (> 0.2)
Tactical crop management (e.g. fertilizer, pesticide use)	Intraseasonal (0.2 – 0.5)
Crop selection (e.g. wheat or chickpeas) or herd management	Seasonal (0.5 – 1.0)
Crop sequence (e.g. long or short fallows) or stocking rates	Interannual (0.5 – 2.0)
Crop rotations (e.g. winter or summer crops)	Annual/bi-annual (1 – 2)
Crop industry (e.g. grain or cotton; native or improved pastures)	Decadal (~ 10)
Agricultural industry (e.g. crops or pastures)	Interdecadal (10 – 20)
Land use (e.g. agriculture or natural systems)	Multidecadal (20 and)
Land use and adaptation of current systems	Climate change

Understanding of ENSO as a driver of climate variability led to advances in forecasting at a seasonal (i.e. ≥ 3-month) lead time (Glantz 2001; Cane et al. 1986; Zebiak et al. 2014). A study by Cane et al. (1994), who showed that ENSO-related Pacific sea surface temperatures were more strongly correlated with maize yields than with seasonal total rainfall in Zimbabwe, stimulated interest in applying seasonal forecasts to smallholder farming in the developing world. A strong and highly visible El Niño event in 1997/98 prompted a surge of effort around the use of seasonal forecasting for smallholder agriculture in the developing world. The advent of seasonal forecasting expanded the lead time of farmer-relevant information that is routinely available into the climate variability timescale, and contributed to the current global interest in climate services. While the longer timescales associated with climate change may influence some farm decisions, they appear to be more relevant to institutional and policy decisions (e.g. plant breeding programmes, market development, investment in infrastructure) that influence options and incentives for farmers.

Farmers are best served by a combination of historic and monitored information, and a seamless suite of prediction that ranges from sub-daily weather to at least seasonal forecasts. Figure 1 illustrates the types of early actions that a farmer is able to take at different points in the agricultural calendar, in response to information at different timescales. Short-term weather forecasts are experienced frequently enough that farmers can quickly develop an intuitive understanding of their accuracy, and rules of thumb for applying the information to management. As we go from weather to climate timescales, agricultural decisions tend to become more context- and farmer-specific, the information becomes more uncertain and hence more challenging to use, and therefore communication challenges and the scope of services required increase. These services may include translating raw climate information into predictions of agricultural impacts or management advisories, training, assistance with planning and organizing response mechanisms, and evaluation and feedback processes to continually improve information products and services. Although farmers out of necessity have a good intuitive understanding of climate variability, training is needed to enable farmers to understand quantitative and graphical presentations of probabilistic climate information. To be useful, raw climate information such as rainfall and temperature must be translated into impacts and management implications within the system being managed. While this is often done through subjective expertise or intuition, quantitative methods to translate historic, monitored and predicted climate information into predicted impacts on agricultural systems

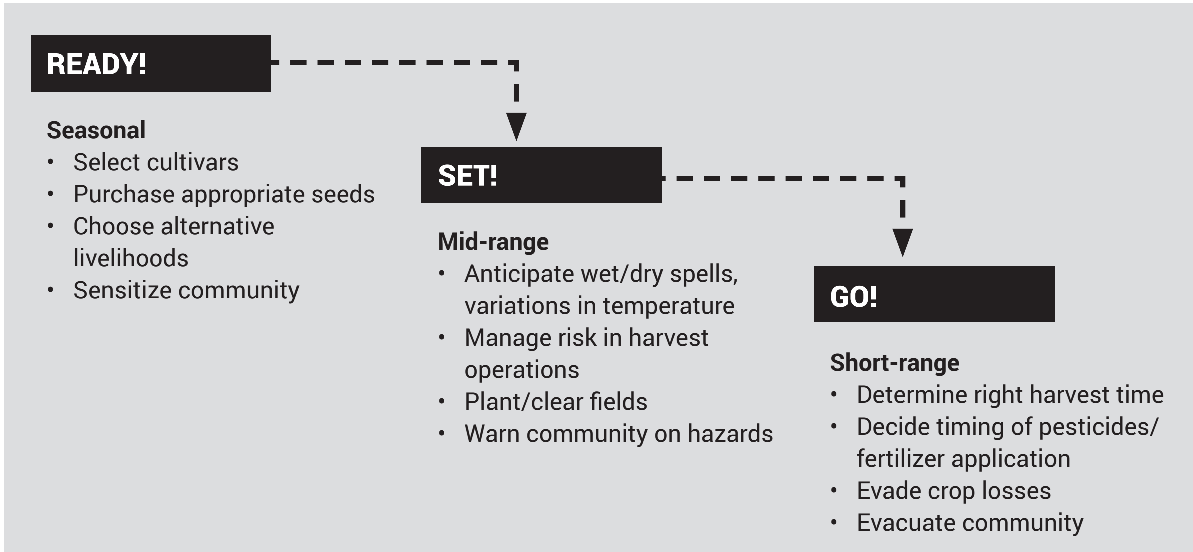

Figure 1. An illustration of possible farmer early actions based on prediction accross timescales. Source, Tall (2013).

(crops, rangelands, pests, diseases), management advisories or decision-support tools is expected to increase the relevance of complex climate information to agricultural decisions.

Providing effective climate services for farmers, beyond the scale of a pilot research project, requires the involvement of a range of institutional stakeholders (Orlove and Tosteson 1999; Hansen 2002; Cash et al. 2006). At a national scale, we conceptualize a chain involving at a minimum national hydro-meteorological services (NHMS), national agricultural research and extension systems (NARES), communication and boundary organizations operating at a local level, institutional and government end users, and the farming communities as the ultimate end users (figure 2). NHMS are the stewards of historic observations; and provide predictions of hydrological and climate variables such temperature, rain, wind and extreme events that can then serve as input to the development of tailored climate services in support of decision-making. Much investment in climate services to date has focused on strengthening the capacity and credibility of NHMS. This investment is essential but not sufficient. As the structure charged with providing research-based knowledge, expert advice and training to farmers, NARES represent a critical second layer in the climate services chain. Where agricultural extension services are effective, they already have the knowledge and trust of farming communities, and have a comparative advantage in translating climate information into management advisories, as one component of the suite of services that they provide. In some countries, NARES have developed quantitative tools to translate climate information into predictions of impacts on agriculture, and to support decision-making by farmers and other agricultural decision-makers. NARES can be thought of as an "intermediary user" or a "co-producer" of climate services, receiving climate information from the NHMS, and translating it into climate-informed advisories tailored to farmers' needs. In developing countries where NARES don't have the capacity to reach large rural populations, other organizations that interact with smallholder farming communities can play a vital role in providing climate services. These include non-governmental organizations (NGOs), community-based organizations (CBOs) such as farmer associations and religious organizations, and the media. End users in the agriculture sector include both vulnerable farming communities (the focus of this report), and a range of institutional and government decision-makers in the agriculture

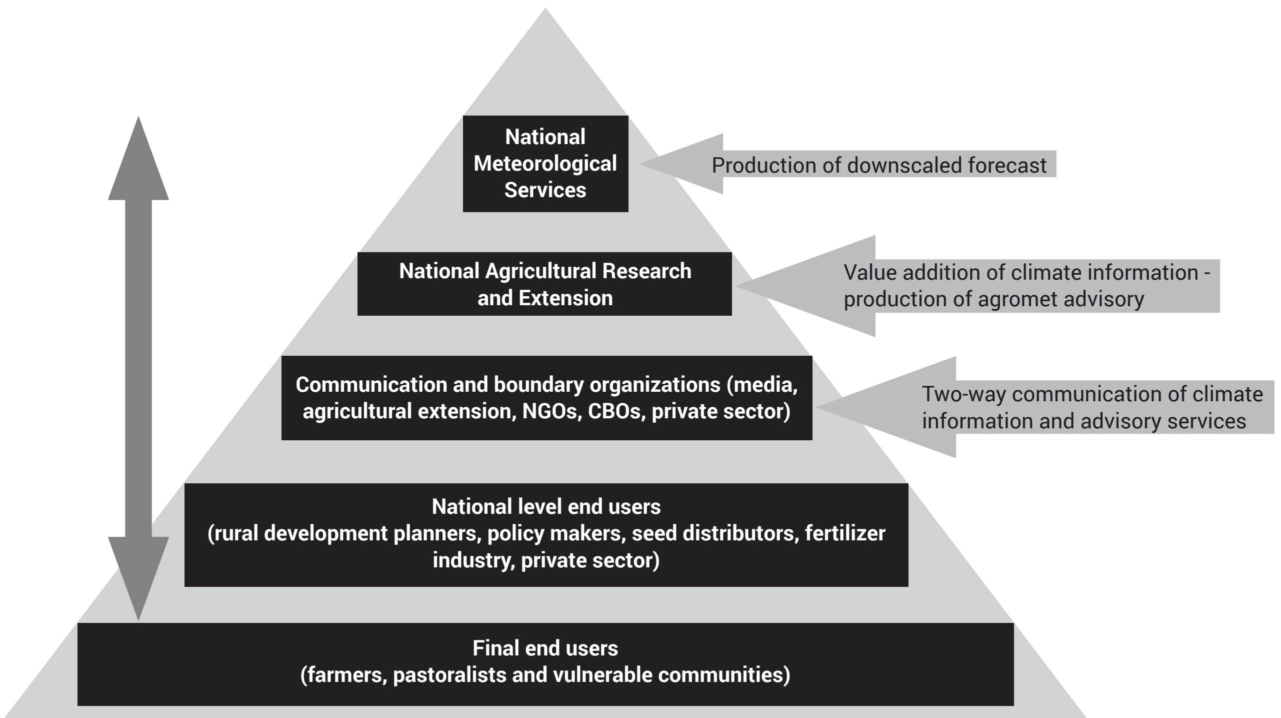

Figure 2. Different levels, roles and users in the chain of climate services at the national level.

sector. From the available evidence, including case studies presented in this report, we believe that institutional structures/arrangements that provide climate services must involve end users as full partners in the co-design and co-production of climate services.

A substantial body of literature highlights conditions that must be met and challenges that must be overcome in order for climate and weather information to improve the livelihoods of vulnerable farmers (e.g. Stern and Easterly 1999; O'Brien et al. 2000; Hansen 2002; Ingram et al. 2002; Patt and Gwata 2002; Cash et al. 2006; Meinke et al. 2006; Suarez 2009; Tall 2010; Hansen et al. 2011; Stigter et al. 2013). While some of the factors that trap smallholder farmers in poverty also limit their ability to act on advance climate and weather early warning information, the majority of the challenges identified reflect communication and institutional failures, and are therefore arguably amenable to intervention (Hansen et al. 2011). Informed by this literature, a workshop on "Scaling up Climate Services for Farmers in Africa and South Asia" (Saly, Senegal, 10-12 December 2012) was held jointly by CCAFS, the United States Agency for International Development (USAID), the World Meteorological Organization (WMO) and the Climate Services Partnership (CSP) (Saly, Senegal, 10-12 December 2012) to identify and prioritize the major challenges, and to identify a way forward to address them. The process concluded that efforts to support smallholder farmers in the developing world through climate services must focus on five key challenges (Tall et al. 2013):

- **Salience:** tailoring content, scale, format and lead time to farm-level decision-making.
- **Access:** providing timely access to remote rural communities with marginal infrastructure.
- **Legitimacy:** giving farmers an effective voice in the design and delivery of climate services.
- **Equity:** ensuring that women, poor and socially marginalized groups have access to and can use available climate services.
- **Integration:** Providing climate services as part of a larger package of agricultural support and development assistance, enabling farmers to act on received information.

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