10 best bet innovations for adaptation in agriculture:

A supplement to the UNFCCC NAP Technical Guidelines

Working Paper No. 215

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Editors

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RESEARCH PROGRAM ON

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Working Paper

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Abstract

Faced with the triple challenges of achieving food security, adapting to the impacts of climate change, and reducing emissions, agriculture has been prioritized by countries as a sector for climate action. The national process of formulating and implementing National Adaptation Plans, which gives effect to the ambitions set out in the Intended Nationally Determined Contributions of countries, is a key instrument that will not only facilitate access to resources, but also advance best practice and implementation of proven and effective adaptation actions. In order to support countries in the elaboration of their National Adaptation Plans, this paper aims to tap into agricultural research for development conducted by CGIAR Centers and research programs, to identify best bet innovations for adaptation in agriculture, which can help achieve food security under a changing climate, while also delivering co-benefits for environmental sustainability, nutrition and livelihoods.

Keywords

Adaptation; agriculture; climate change

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Improving smallholder dairy – enhanced incomes and greater climate resilience

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Alternate wetting and drying in rice systems

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Solar Irrigation Entrepreneurs: expanding access to affordable irrigation and enhancing resilience

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Digital agriculture – from tailored advise to shared value with millions of farmers

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Climate-informed advisories to enhance production and resilience

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Weather index-based agricultural insurance for countries and farmers

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Scaling up financing for climate change adaptation in agriculture

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Contents

Case studies

Acronyms

ACIAR	Australian Centre for International Agricultural Research
ACRE	Agriculture and Climate Risk Enterprise
AfricaRice	Africa Rice Center
AMRIS	Angat-Maasim River Irrigation System
AWD	Alternate wetting and drying
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CDM	Clean Development Mechanism
CIAT	International Center for Tropical Agriculture
CIFOR	Center for International Forestry Research
CIMMYT	International Maize and Wheat Improvement Center
CSA	Climate-Smart Agriculture
DTMA	Drought Tolerant Maize for Africa
EADD	East Africa Dairy Development
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FISH	CGIAR Research Program on Fish AgriFood Systems
FMNR	Farmer managed natural regeneration
FSSP	Food Staples Sufficiency Program
FTA	CGIAR Research Program on Forests, Trees and Agroforestry
GFCS	Global Framework for Climate Services
GHG	Greenhouse gas
GOFC-GOLD	Global Observation of Forest Cover and Land Dynamics
GRiSP	Global Rice Science Partnership
HTMA	Heat Stress Tolerant Maize for Asia
ICRAF	World Agroforestry Centre
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
IRRI	International Rice Research Institute

IWMI	International Water Management Institute
M&E	Monitoring and evaluation
MFIs	Micro Finance Institutions
MRV	Monitoring, reporting and verification
NAMA	National Appropriate Mitigation Actions
NAPs	National Adaptation Plans
NARES	National Agricultural Research and Extension Systems
NDC	Nationally Determined Contribution
NERICA	New Rice for Africa
NMS	National Meteorological Services
NPV	Net present value
OFSP	Orange-fleshed sweetpotato
PhilRice	Philippine Rice Research Institute
PV	Photovoltaic
REDD+	Reducing Emissions from Deforestation and forest Degradation, and enhancing forest carbon stocks
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USAID	United States Agency for International Development
USD	United States Dollar
WMO	World Meteorological Organization

Introduction

Agriculture is at the intersection of three major challenges in the context of climate change. Firstly, the sector is expected to produce 60% more food by 2050 (Alexandratos & Bruinsma 2012). Secondly these production increases need to occur even as the impacts of climate change are becoming evident in crop, livestock and fisheries systems globally (Porter et al. 2014). Finally, the sector contributes 19%–29% of global anthropogenic greenhouse gas (GHG) emissions (Vermeulen et al. 2012), and will need to reduce emissions significantly by 2030 in order to achieve the global goal of limiting warming to 2^{o} Celsius (Wollenberg et al. 2016).

Taking cognizance of the critical role of agriculture, both in climate change adaptation and mitigation, countries have overwhelmingly prioritized climate actions in the sector. As part of the Paris Climate Agreement, of the 138 countries that included adaptation in their Intended Nationally Determined Contributions (INDCs), almost all (127) indicated agriculture as a priority, and 104 countries included agriculture within their mitigation targets (Richards et al. 2016). As countries move forward in implementing priority actions, the national process of formulating and implementing National Adaptation Plans (NAPs) gives effect to the ambitions set out in the INDCs. It will be a key instrument that will not only facilitate access to resources, but also advance best practice and implementation of proven and effective adaptation actions.

In this context, as countries embark on NAP formulation and implementation, this paper aims to tap into decades of agricultural research for development conducted by CGIAR Centers and research programs, to identify the leading innovations for adaptation in agriculture, which can help countries and communities adapt to the impacts of climate change, while sustaining productivity, and delivering co-benefits including for environmental sustainability, nutrition and livelihoods. This paper also aims to provide guidance for implementers in terms of costs and benefits, suitable geographies, timeframes for implementation and approaches to monitoring and evaluating results from these innovations.

Achieving co-benefits from adaptation in agriculture

While adaptation is the priority in agriculture in order to achieve global food security, adaptation actions in agriculture are also well placed to provide co-benefits in terms of environmental sustainability, nutrition and livelihoods, and specific opportunities to achieve co-benefits have been captured across many of the ten innovations identified. For example, while stress tolerant varieties (innovation 3) can help cope with increased temperatures, drought and salinity, such varieties can also deliver co-benefits for nutrition, pest and disease tolerance, and help reclaim salinized land (in the case of rice). Realizing opportunities for achieving co-benefits will be key to countries as they try to make best use of available resources, and achieve the Sustainable Development Goals (SDGs).

Identifying suitable geographies

The innovations described in this paper do not all have universal applicability, and it is important to choose the geographies for implementation, to avoid consequences related to maladaptation. It may be possible to adapt some of the innovations to other locations, but it will need careful planning to ensure that the innovation is tailored to local realities. For example, the innovation around solar irrigation entrepreneurs (innovation 6) is focused in the Ganges river basin of India, but will have applicability in other regions, subject to careful adaptation to those locations. For each innovation, we have included a section on its geographic suitability, to provide implementers with guidance on priority geographies for the innovation. However, while these sections provide a sense of big wins and opportunity areas, further prioritization at the district and county level are needed. Further tools and resources for context-specific prioritization are available for this, notably Climate-smart agriculture (CSA) Plan which provides an approach to analysing a given situation, targeting and prioritizing, programme support, and ongoing monitoring and evaluation (CCAFS, CIAT, ICRAF, 2015)

Timeframes for implementation

Adaptation actions in the agricultural sector have different timeframes for implementation, and indeed to generate results. For example, homestead fish ponds can deliver returns on investments in 1-3 years in tropical environments (innovation 2), whereas improving climate information services (innovation 8) depends on the capacity of meteorological institutions within a given country. Implementers will have to develop portfolios of interventions which deliver benefits in both the short and long term. Each innovation presented within this paper includes the timeframes for implementation, to help implementers select solutions which suit their planning timeframes.

Measuring progress towards climate goals

It is important to monitor and evaluate the results delivered by adaptation actions in agriculture, to enable countries to report progress towards their goals as part of the global stocktakes planned under the Paris Climate Agreement. It is also important for monitoring and evaluation approaches to be consistent and comparable. Therefore we propose a framework which involves two types of indicators applicable at different stages of the planning and implementation cycle:

1. **Process indicators**: These allow tracking the actual number of beneficiaries trained (e.g. including gender implications), implementing, accessing and /or benefiting from a given innovation, for example through household level surveys. These indicators are collected at the stage of implementation, and allow implementers to monitor the progress of the innovation to ensure that it reaches set objectives.
2. **Outcome indicators**: These enable implementers to assess downstream adaptation benefits delivered by innovations in terms of decreased vulnerability, increased food security, production/livelihood stability and/or adaptive capacity. These indicators are collected at the outcome or impact stage of the project, when the benefits are evident.

Quinney et al. (2016) originally proposed a third set of indicators – **Readiness indicators** (Figure 1). These help to assess country readiness through existing enabling policies, strategies, plans, and markets, for a specific innovation to be implemented. These kinds of indicators are useful at the planning/targeting stage of an intervention, giving policy makers, investors and implementers insights into the enabling environment for the innovation, but are not described further in this publication.

Figure 1. Indicators for monitoring progress towards climate goals (Quinney et al. 2016).

In this paper, for each of the ten innovations, we have identified relevant process and outcome indicators, to enable effective use of these indicators as interventions are designed and implemented.

Addressing challenges in implementation

While the proposed innovations do represent promising actions which countries can undertake, their implementation is not without challenges. For example, unavailability of data, poor farmer understanding and weak regulatory environment are among the major challenges which affect the development of weather index insurance (innovation 9). We have endeavoured to identify the key challenges on each of the innovations, so that implementers can plan ahead and overcome these challenges, for example by putting in place appropriate capacity-building efforts.

Enabling policy and business environment

Finally, the success of these innovations not only depend upon the technical features, but also on the existence of a favourable enabling environment, including favourable policies, business opportunities and adequate institutional capacities to implement and scale up these innovations to meaningful levels. Many of the case studies of success of these innovations arise from instances where a favourable enabling environment was put in place, for example in Case study 1 on agroforestry (innovation 1), a partnership between the World Agroforestry Centre (ICRAF), Mars Incorporated, and national partners, was able to scale up agroforestry in Ivory Coast, thanks to the Government's plans to rehabilitate 40% of the country’s cocoa orchards by 2023.

1. Agroforestry to diversify farms and enhance resilience

Agroforestry involves the integration and use of trees in crop fields, farms and across agricultural landscapes. Trees buffer climate change impacts and variability and diversify land use and farming systems, providing additional livelihood and environmental benefits not delivered through land management without trees. There is huge scope to increase and better manage tree cover on farms and across agricultural landscapes. Implementing agroforestry involves promoting a diverse set of options (comprising innovation in technology, markets and policy) that need to be matched to variation in environmental and social context. Options range from intensification of extensive parkland systems in the Sahel and fertilizer trees across East and Southern Africa, to multi-strata tree-cropping including coffee, cocoa, and rubber (see Case study 1) and home gardens in more humid zones, and silvopastoral systems that integrate trees with livestock on rangelands.

Case study 1: Vision for change in Ivory Coast

"Vision for Change" supported by Mars Incorporated and managed by ICRAF, in collaboration with national partners, aims to contribute to the Ivory Coast Government's plans to rehabilitate 40% of the country's cocoa orchards by 2023. It is increasing farmers' incomes by rehabilitating aging cocoa farms with improved germplasm, training on best practices for tree and disease management, and encouraging agroforestry to buffer against climate variability and change, improve soil fertility and increase profits. More than 100 different tree species have been found in Ivorian cocoa agroforests in one region and 95% of farmers report wanting to grow more trees on their land, particularly when the trees have market value. By 2016, 34 communities had benefited from the program and by 2020, Mars hopes that more than 10,000 farmers will have more productive cocoa farms through training and services.

Adaptation benefits

Trees in agricultural systems confer adaptation benefits through buffering climate change, variability and extreme events, diversifying farming systems both ecologically and economically and increasing resilience of soils, livelihoods and landscapes. Appropriately managed tree shade over crops reduces ambient temperature by typically around 2°C allowing temperature sensitive crops like coffee to continue to be grown at locations where temperatures are increasing, as well as leading to higher yields of staple food crops through reducing heat stress and extending the grain filling period. Tree shade also increases animal production by reducing heat stress in silvopastoral systems. Shade also reduces bare soil evaporation and improves water use efficiency of crops, making better use of water during drought periods. In many circumstances trees increase water infiltration, reducing soil erosion and flood risk. Tree cover plays an important role in water cycles at landscape and continental scales, with groundwater recharge in the seasonally dry tropics being maximized with an intermediate level of tree cover and changes in tree cover in one place (e.g. the East African highlands) impacting rainfall elsewhere (e.g. the Sahel) through re-precipitation of transpired water transferred over large distances in the atmosphere. Trees diversify livelihoods both directly, through tree products that may be consumed or sold such as fruit, nuts, timber, firewood and fodder; and through sustainable intensification involving interactions with other components, as shown by the CGIAR Research Program on Forests, Trees and Agroforestry (Figure 2). For example, producing firewood (the main energy source for cooking for 760 million people in Africa alone) reduces labour required for collection that can be redirected to other livelihood options while on farm fodder production, increases and stabilizes livestock production. Trees are often complementary to other components: producing fodder and food at times when annual crops or grasses do not and stabilizing income through product diversification.

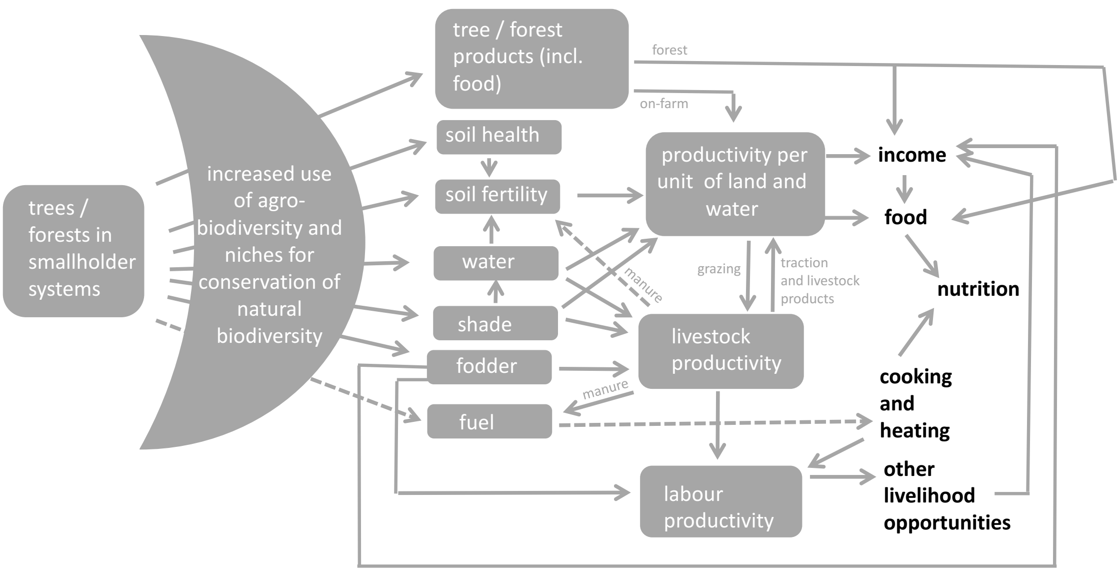

Figure 2. How trees can sustainably intensify smallholder-farming systems through interactions with other components (FTA 2017).

Co-benefits

Trees on farms further a low carbon development pathway by increasing carbon storage in biomass vegetation, in soils, and through the production of substitutes for products that have higher emissions (e.g. firewood, construction materials). At the plot level, agroforestry systems accumulate between 1.1 and 28.2 t CO_2 ha^{-1} yr^{-1} in biomass and 3.7 and 27.3 t CO_2 ha^{-1} yr^{-1} in soils, though higher rates have been documented. When leguminous trees and shrubs are used, agroforestry systems tend to produce similar levels of nitrous oxide emission from the soil that occurs when farmers use chemical fertilizer (e.g. 1% of available nitrogen).

Agroforestry systems also deliver co-benefits for nutrition; a positive relationship between indicators of dietary quality of children under five and landscape scale tree cover has been found in Africa, associated with maximum fruit and vegetable consumption at an intermediate level of tree cover. Trees often provide key micronutrients and vitamins (notably A, C and B6) which not provided sufficiently by crop staples.

Costs and benefits

High value tree crops can produce annual incomes that enable smallholders to exit poverty. For instance, as shown by ICRAF, in the cases of son tra (*Docynia indica*) and longan (*Dimocarpus longan*) when intercropped with maize on sloping land in northern Vietnam, an additional income is generated in the order of magnitude of USD 2,000-3,500 ha^{-1} yr^{-1}. Additional value over a maize monoculture with a 15-year time frame and 10% discount rate is in the range of USD 8,000 to 15,000 ha^{-1} with break-even after 5 to 8 years. Planting fodder grasses on contours can bridge the time between investment and economic returns, a common constraint to agroforestry investments, by providing immediate income and enabling feeding animals in stalls and thus, reducing risks of livestock damage to young trees. While the net present value (NPV)—on a 20-year cycle and considering 8% discount rate—from silvicultural improvements for timber production alone in Indonesia was not attractive for farmers or investors at around USD 1,200 ha^{-1}, combining with non-timber forest products increased the NPV to USD 5,000 ha^{-1}, intercropping to around USD 6,700 ha^{-1} and sustainable intensification with all three combined to USD 11,600 ha^{-1}. Much less intensive management required for farmer managed natural regeneration (FMNR) of trees in the Sahel (Mali, Burkina Faso, Niger and Senegal) resulted in extra income from tree products. All these values do not include the value of ecosystem services derived from trees. Investing in trees represents an investment in the environment. Once established, the trees can access more, and often complementary resources, to herbaceous crops or pasture, increasing net productivity and producing large quantities of high value products, often amenable to added value through local processing.

Geographies

Agroforestry is among the most diverse land management interventions available and hence, there are successful examples of agroforestry available for virtually every region and country globally. Some of the most widespread and promising are silvopastoral systems in Latin America, shade coffee and cocoa in Latin America, Africa and Asia, farmer managed natural regeneration in West Africa, and homegardens of fruit trees in Southeastern Asia, all of which have been implemented on millions of hectares. Diversity is the key feature of agroforestry. With each agroforestry intervention, there are countless small adaptations which can tailor the system to farmer and community needs, and change the type and quantity of benefits derived. It is therefore critically important to match specific agroforestry interventions to the environmental conditions and social context taking into account local knowledge.

Timeframes for implementation

The timeframe to receive benefits from agroforestry depends on the initial conditions. When developing agroforestry from cropland, benefits can be achieved in as little as six months (e.g. soil fertility improvements with improved fallows with fast growing leguminous shrubs) to 3-5 years when planting fruit trees from seedlings, to a decade when agroforestry is viewed as part of natural regeneration processes. Even during long intervening periods, intermediate benefits and outcomes can be derived by farmers, through mixed species planting with a sequencing of products and harvest of by-products such as fuelwood, fodder and benefits of shade. In some locations, agroforestry can also be initiated by selective removal of trees, leaving valuable individuals, in which case there may be little or no time lag.

Monitoring and evaluation

Monitoring the benefits of agroforestry interventions (e.g. intercropping, farmer managed natural regeneration, fallows, silvopasture etc.), can help countries report progress against their climate goals in the United Nations Framework Convention on Climate Change (UNFCCC)'s global stocktakes. Field-based household level surveys designed to address process indicators will allow to track actual # of beneficiaries trained for and/or adopting agroforestry related practices whereas outcome indicators will enable to assess their adaptation benefits in terms of decreased vulnerability/increased stability and/or improved adaptive capacity (e.g. positive changes in households' livelihoods, diet and income diversification, ability to recover from/buffer against climate-related shocks like droughts or increases in household saving/investment capacities). At a more fine-tuned level, adaptation co-benefits at the farm level can be evaluated using more technical quantitative indicators to measure improved productivity, positive changes in soil characteristics and resource use efficiency (e.g. water, fertilizers). Estimation of carbon stock changes in tree biomass over large areas can be done through field samples combined with allometric equations (which relate tree dimensions to biomass) or through remote sensing approaches.

Challenges in implementation

The most widespread challenges to implementing agroforestry are i) a need to bridge the time-gap between investment in establishing trees and obtaining returns (being tackled technically by sequencing production and through novel government and private sector financing mechanisms) and, ii) the lack of enabling conditions in respect of markets for agroforestry products and policies that promote rather than discourage tree management. These include forest legislation (farmers may not be legally able to, or may require permission to, utilize trees even on their own land, and their presence may affect whether land is designated as forest and thereby use becomes restricted) and, land tenure (where not secure, long-term investment in trees may be risky). Trade in many tree and forest products is either regulated or underdeveloped. Recent advances in enabling policies have been made in several countries notably India, Peru, Brazil, Vietnam, Indonesia, Ethiopia, Rwanda and Uganda and it is necessary to consider technology, market and policy interventions in tandem when implementing agroforestry at scale.

Key resources

<u>Carbon sequestration from agroforestry:</u>

Kim D-G, Kirschbaum MUF, Beedy TL. 2016. Carbon sequestration and net emissions of CH_4 and N_2O under agroforestry: Synthesizing available data and suggestions for future studies. *Agriculture, Ecosystems and Environment* 226:65-78. Available online at: https://doi.org/10.1016/j.agee.2016.04.011

<u>Overview of research:</u>

Nair PK, Garrity D (eds). 2012. *Agroforestry: The future of global land use.* Dordrecht, The Netherlands: Springer. Available online at: https://link.springer.com/book/10.1007%2F978-94-007-4676-3

Guide for field practitioners:

Xu J, Mercado A, He J, Dawson I (eds). 2013. *An agroforestry guide for field practitioners.* Kunming, China: World Agroforestry Centre. p 72. Available online at: http://www.worldagroforestry.org/downloads/Publications/PDFS/B17460.pdf

World Agroforestry Centre

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2. Aquaculture to enhance nutrition and diversify incomes

Fish are the largest source of wild protein left on the planet. For more than 3 billion people, some 40% of the planet's population, fish makes up a fifth or more of their animal protein intake. Climate change threatens the productivity of fisheries, and the livelihoods of many dependent communities. Fish producing countries throughout Africa, Asia and Latin America face climate change challenges, but Africa is especially at risk, with 14 of the world's 20 most vulnerable countries found within the continent (Allison et al. 2009).

Aquaculture, or the farming of fish and other aquatic products, is the world's fastest growing food production sector, now supplying half of global seafood consumption. Investing in fish farming is one key strategy for adaptation to changing environments, whilst also contributing to greater resilience of smallholder farms and creating income and employment in a food production sector that can meet increasing global demand for animal source foods in an environmentally sensitive manner.

Fish supply globally will need to double by 2050 (Waite et al. 2014), but Africa faces particularly acute challenges to manage fisheries and produce a sustainable supply of farmed fish. However, efforts are ongoing to support sustainable aquaculture development in Africa (e.g. Case study 2).

Case study 2: Smallholder aquaculture in Northern Province, Zambia

WorldFish and partners in northern Zambia are building the capabilities of smallholder farmers for fish farming, improving productivity through use of local feeds and fertilizers, and improving diversity of fish production systems through introduction of small nutritious fish into ponds. Research has improved hatchery production of a local tilapia species (*Oreochromis tanganicae*), as well as identified potential nutrient rich small species for aquaculture. Farmers have begun calling these aquaculture systems 'relish ponds', which enables them to grow a diverse range of small, indigenous, nutrient-rich fish species on a diet of algae, bacteria, microbes, and detritus for use as a 'relish' (to accompany starch-based staples). Research shows that certain small species are robust and resilient to local wetland conditions and can also be grown in mixed systems with tilapia for sales and income. Consumption studies show that these small species are regularly consumed in rural and urban areas with high micronutrient content. These 'relish' ponds provide resilience to climate shocks due to the diversity of species and low-cost inputs and diversification of the farm production system (Genschick et al. 2017).

Adaptation benefits

As countries endeavour to achieve food self-sufficiency through closing yield gaps, food production systems may render themselves more vulnerable to shocks. These shocks may be either weather-related or financial (e.g. fluctuating crop, fertilizer, seed, or fuel prices). Aquaculture provides several adaptation benefits for smallholder farmers.

Fish farming can increase farmers' adaptive capacity by providing an alternative supply of fish to depleted wild fisheries, as well as an additional nutrient rich and widely accepted animal food for homestead consumption and sales. Fish ponds on smallholder farms help diversify income for farmers and thus enable them to increase resilience in the face of shocks. Fish ponds can act as water reservoirs that help buffer against drought, whilst offering several services to both crop and livestock farming. Fish in ponds themselves can also act as a 'capital' that can be used for food or cash, another adaptation benefit. In tropical deltas affected by salinity intrusion and extreme weather, such as in Bangladesh, fish ponds provide income and food in regions less suitable for agricultural crops and livestock, as well as a mechanism that may help coping after disasters (Karim et al. 2014).

Co-benefits

There are many co-benefits from fish farming in ponds. These include potential benefits for biodiversity, environmental sustainability and especially nutrition. Pond farming of tilapia, a species that feeds low in the food chain, can be produced with low carbon footprint (Henriksson et al. 2017), thus helping to mitigate the carbon footprint associated with the growing demand for animal foods. A smallholder pond can introduce a water supply that can be used for crops, vegetables and livestock, increasing resilience of smallholder farming systems. The addition of healthy nutrient rich fish to farms can also contribute to dietary diversity and the widespread challenge of undernutrition.

Costs and benefits

Aquaculture is a profitable farming activity for many small-scale farmers, though sustainability requires that farmers have access to quality inputs such as fish seed and feed, as well as ready access to markets for fish sales. WorldFish research in several countries in Africa shows that small household ponds can be readily constructed on many farms throughout the region, and that moderately productive and well-managed ponds farming tilapia can yield between USD 1,000-3,000 ha^{-1} yr^{-1} of profit for farm households, whilst providing a ready source of fish for consumption, and water for crops and livestock. Clustering of fish farming households within suitable locations and development of fish producer organizations can greatly facilitate technology uptake, access to feed and seed, and fish marketing.

Geographies

Productive and profitable fish farming requires suitable water, soils, infrastructure and market access, but many countries throughout Africa, Asia and Latin America have suitable sites for fish farming, combined with strong and growing market demand for fish (Waite et al. 2014). WorldFish research in South and Southeast Asia and Africa shows that small household ponds can be readily constructed throughout these regions, and that moderately productive smallholder ponds farming tilapia can yield between USD 500-2,000 yr^{-1} of profit for farm households, whilst providing a ready source of fish for homestead consumption, and water for adjacent crops and livestock. Clustering of households within suitable locations and development of fish producer organizations can greatly facilitate technology uptake, access to feed and seed, and fish marketing.

Timeframes for implementation

Aquaculture systems range from those using existing water bodies, to the construction of holding facilities of different complexities and levels of investments. Homestead fish ponds can return on investment in 1-3 years. Fish grow fast in tropical environments, allowing an early flow of food and income following investment, as well as creating opportunities for employment in processing and retailing, jobs often associated with women. Successful aquaculture production is, however, also reliant upon existing infrastructure for fish seed, feed supply and an enabling policy and institutional environment. These national-level supporting systems can be far more time consuming, from 5-10 years, to establish and require larger investments. Thus, introduction of fish farming can take anything from months to years.

Monitoring and evaluation

The benefits of aquaculture related interventions impact the adaptation (increasing resilience) pillar of the global stocktake. National Departments of Fisheries regularly monitor aquaculture systems, facilitated by use of new remote sensing and big data collection techniques that could efficiently screen for ponds and pond productivity. These systems can be leveraged to monitor adaptation benefits accrued by these systems. Field-based household level surveys designed to address process indicators will allow to track actual # of beneficiaries trained for and/or implementing aquaculture systems whereas outcome indicators will enable to assess their adaptation benefits in terms of decreased vulnerability/increased stability and/or improved adaptive capacity (e.g. positive changes in households' livelihoods: diet and income diversification, ability to face or recover from a climate-related shocks like droughts, increases in household saving/investment capacities). At a more fine-tuned level, adaptation co-benefits at the farm level can be evaluated using more technical and quantitative indicators to measure improved productivity and positive changes in resource use efficiency.

Challenges in implementation

Aquaculture faces various challenges to grow sustainably, including a requirement for upfront investments in ponds or cages, seed and feed, market access, pests and diseases and water availability in some climates with strong seasonality. As an emerging food production sector in some countries, a lack of access to knowledge and enabling policy and institution framework can also constrain development. These challenges may be overcome by new investments in policy and institutional frameworks, trainers and services, as well as fish breeding programs and feeding systems. The enabling of local services and use of mobile knowledge transfer techniques to increase access and reach of technical information and market knowledge can also help.

Key resources

Climate change impacts on fisheries:

Allison EH, Perry AL, Badjeck M-C, Neil Adger W, Brown K, Conway D, Halls AS, Pilling GM, Reynolds JD, Andrew NL, Dulvy NK. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10:173–196. Available online at: http://onlinelibrary.wiley.com/doi/10.1111/j.1467-2979.2008.00310.x/abstract

Aquaculture development in Zambia:

Genschick S, Kaminski A, Cole S, Tran N, Chimatiro S, Lundeba M. 2017. *Toward more inclusive and sustainable development of Zambian aquaculture.* Program Brief: FISH-2017-07. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Available online at: http://pubs.iclarm.net/resource_centre/FISH-2017-07.pdf

Sustainable intensification of aquaculture:

Waite R, Beveridge M, Brummett R, Castine S, Chaiyawannakarn N, Kaushik S, Mungkung R, Nawapakpilai S, Phillips M. 2014. *Improving Productivity and Environmental Performance of Aquaculture.* Working Paper, Installment 5 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute. Available online at: http://www.wri.org/publication/improving-aquaculture

Training manual on Tilapia culture and dyke cropping:

WorldFish. 2011. *Training Manual on Improved Tilapia Culture and Dyke Cropping in Pond/Gher.* Dhaka: Cereal Systems Initiative for South Asia in Bangladesh (CSISA-BD), WorldFish Center.
Available online at: http://pubs.iclarm.net/resource_centre/CSISA-Tilapia-manual.pdf

WorldFish

CGIAR | RESEARCH PROGRAM ON Fish

3. Stress tolerant varieties to counter climate change

Climate change affects the yield of crops through increased exposure to high temperature, water, salinity and flooding stresses. The CGIAR has produced rice, maize, wheat, sweetpotato and potato varieties that have increased tolerance to climatic stresses and these have been rolled out in Africa and Asia to increase smallholder resilience to climate change. These benefits came about by either increasing the physiological resilience to climatic extremes or the use of early-maturing varieties that allow cropping calendars to be adjusted to cope with seasonally unfavourable conditions (Wassmann et al. 2009a). Strengthened breeding systems, using the latest technologies, together with more open international exchange of germplasm, and rapid change in varieties are fundamental components of this adaptation strategy (Reynolds et al. 2016; Atlin et al. 2017; Grüneberg et al. 2015).

Case study 3: Drought tolerant maize for Africa

For the past decade the Bill & Melinda Gates Foundation and USAID have invested in stress tolerant maize for Africa. Investments have focused on three main areas: improving breeding, strengthening the seed sector and reducing bottlenecks associated with adoption. To date, over 200 varieties have been released across 13 countries in sub-Saharan Africa, which has the potential to generate between USD 362 million to USD 590 million over a 7-year period, through both yield gains and reduced yield variability (Kostandini et al. 2013). Most importantly, breeding for stress tolerance has not been at the expense of yield. Stress tolerant maize yielded approximately 20% more under stress prone conditions, with no yield penalty in favourable years/environments leading to a reduction in year-to-year yield variability (Setimela et al. 2017a). More than 52,000 metric tonnes of certified improved seed was produced, enough to plant 2 million hectares by 5.2 million households and impacting as many as 41 million people. Yield gains in stress prone environments significantly increased household income and food security (Lunduka et al. 2017).

Adaptation benefits

- **Maize** - on-farm trials show climate resilient maize varieties yield 20% more than current commercial varieties in low yielding environments, and double in severe stress environments, such as the El Niño event of 2015/16 (Setimela et al. 2017a and b). In drought prone regions of Zimbabwe increased yields of climate resilient maize translated to USD 240 ha^{-1} income or nine months of extra food (Lunduka et al. 2017).
- **Sweetpotato** – Fifteen pro-vitamin A rich, drought tolerant orange-fleshed sweetpotato (OFSP) varieties were released in Mozambique in 2011 (Andrade et al.

2016), with an additional four varieties in 2016 (Andrade et al. 2017), using the accelerated breeding scheme approach. These varieties now account for one-third of the sweetpotato produced in Mozambique. Yield has improved concurrently, with an average yield gain of 0.3 t ha^{-1} yr^{-1}.

- **Rice** - an estimated 700,000 farmers in India and Bangladesh have adopted improved stress tolerant rice varieties. Farmers in Odisha State, India, who adopted the flood-tolerant Swarna-Sub1 variety, obtained an average yield benefit of 232 kg ha^{-1} (11%), with a maximum of 718 kg ha^{-1} (66%) when floods lasted up to 13 days (GRiSP 2013). In Uttar Pradesh, India, the average yield of the drought-tolerant variety Sahbhagi Dhan in the severe drought year 2015 was 1.0-3.9 t ha^{-1} higher than that of other varieties (GRiSP 2015). In SSA, around 2010, NERICA rice varieties occupied about 8% of the cultivated rice area of 6.8 million ha across 13 rice-growing countries (Diagne et al. 2015). By 2013, adoption had spread to 16 countries, which increased rice yields by 319 kg ha^{-1} and helped lift about 8 million people out of poverty.
- **Wheat** – continual yield gains for both heat and drought tolerance have been demonstrated through extensive trials worldwide (Manes et al. 2012; Gourdji et al. 2012). The benefits are seen in most wheat growing countries and especially in less developed countries (see also Lantican et al. 2016) with yield gains varying by region but are typically between 0.5 and 1% yr^{-1}.
- **Potato –** potato varieties tolerant to drought, heat and salinity have been developed and tested. These include the Tacna, Unica and Maria Bonita varieties in Peru, Kinga, Meva, Kinigi varieties in Africa and the Raniag variety in the Philippines. Tacna was also introduced to China under the name Jizhangshu 8 and by 2008 covered over 20,000 ha. Another example is the variety Sarnav, released in Central Asia (Uzbekistan and Tajikistan) with tolerance to soil salinity and drought.

Co-benefits

Nutrition: Stress tolerant varieties have the ability to deliver co-benefits for nutrition, by combining traits associated with climate variability (e.g. drought and heat stress) and nutrition (pro-vitamin A, iron, zinc or quality protein maize). Vitamin A rich orange-fleshed sweetpotato varieties are being disseminated in 14 SSA countries and have reached over 3 million households (Low et al. 2017). In Malawi, Zambia and Zimbabwe maize varieties are now on the market with both drought tolerance and high pro-vitamin A content. Research is currently underway to develop drought and heat tolerant, nutritionally enhanced maize rich in pro-vitamin A and zinc.

Pest and disease tolerance: An indirect benefit of investing in breeding for climate-related stresses is that strengthened breeding pipelines are able to quickly and efficiently incorporate tolerance to other emerging threats such as pests and diseases.

Salinized land reclamation: The growing of salt-tolerant rice has huge opportunities to reclaim and restore salt-salinized lands. Increased yields and income will contribute to overall increased farmers' livelihoods, food and nutrition security and welfare.

Low carbon development: Rice environments affected by salinity and droughts are inherently associated with low methane emissions, hence, the propagation of salinity-tolerant and drought-tolerant rice varieties present pathways of low carbon development. Likewise, the replacement of traditional varieties grown by short-maturity varieties has reduced flooding periods and thus, the amount of methane emitted per season.

Costs and benefits

The adoption of climate-smart maize across 13 African countries has the potential to generate between USD 362 million to USD 590 million over a 7-year period, through both yield gains and an increase in yield stability (Kostandini et al. 2013).

Drought-tolerant Sahel rice varieties introduced by AfricaRice in 1994/95 have helped adopters in Senegal to significantly increase yields and incomes by an average of 872 kg ha^{-1} and USD 227.65 per cropping season respectively (Basse et al. 2015). The internal rate of return and the economic internal rate of return are evaluated at 81% and 72%, respectively. The net present value (NPV) of benefits was estimated at USD 24.6 million.

Increased yield from improved wheat varieties, including increased heat and drought tolerance, has resulted in an increase in annual revenue of between USD 2-3 billion and mainly for farmers and resource poor consumers in the developing world, demonstrating a staggering return on investment of 100:1 (Lantican et al. 2016). Direct benefits to smallholder farmers and poor consumers are supported by studies like Shiferaw et al. (2014) in Ethiopia and in other studies (see Reynolds et al. (2017). Gourdji et al. (2012) showed that improved varieties are already delivering climate resilience, and more recent analysis have demonstrated the potential for further impacts under heat and drought stress (see Reynolds and Langridge, 2016).

Geographies

The breeding for and distribution of improved stress tolerant varieties is never a completed task given the continual changing climate that breeders need to target as well as ever evolving threats from pests and diseases. Whilst efforts have concentrated largely on sub-Saharan Africa and South Asia, the potential target areas are huge.

Drought Tolerant Maize for Africa (DTMA) and High Temperature Maize for Asia (HTMA) have been crucial in terms of breeding for and distribution of improved stress tolerant varieties of maize. DTMA has catalysed the release of more than 230 maize varieties in eastern Africa (Ethiopia, Kenya, Tanzania, and Uganda); southern Africa (Angola, Malawi, Mozambique, Zambia, and Zimbabwe); and in West Africa (Benin, Ghana, Mali, and Nigeria) between 2007 and 2015. HTMA has seen the licensing of 18 precommercial heat tolerant maize hybrids; 6 have broad adaptation across agro-ecological zones in South Asia (suggesting they likely possess both heat and drought tolerance) and 12 hybrids had good adaptation to specific mega-environments in Bangladesh, Bhutan, India, Nepal and Pakistan.

With regard to wheat, CGIAR-related improved varieties covered about 64% of the 165.7 million hectares sown in 2014 (Lantican et al. 2016), representing three-quarters of the world's wheat area (222 million hectares). In South Asia where over 100 million tonnes of wheat is consumed each year, 92% of the varieties released contained CGIAR breeding contributions.

Recognizing the importance of breeding for locally adapted varieties that concurrently meet taste preferences of different communities, a major investment was made to increase sweetpotato-breeding capacity in SSA. Varieties from the nutrition-smart and climate-smart program have now been provided to 13 countries in sub-Saharan Africa (SSA). Some of the drought-tolerant OFSP varieties have now been released in Madagascar, Ivory Coast, and Abu Dhabi, and included as parents in other SSA breeding programs. In addition, since 2009, 14 SSA countries have released 40 early-maturing varieties (mature in 90-120 days after planting) that are ideal for shortening rainy seasons.

Distribution of drought, flood, and salinity tolerant rice varieties have concentrated so far on SSA and South Asia, especially Bangladesh and India where an estimated 700,000 farmers have adopted improved stress tolerant rice varieties to date. Potential targets areas are huge (http://strasa.irri.org/stresses/): drought regularly affects 23 million hectares of rainfed rice in South and Southeast Asia; flooding afflicts some 20 million hectares in Asia, whereas as much as one-third of the rainfed lowland areas in sub-Saharan Africa are thought to be affected by submergence; in India and Bangladesh alone, productivity of more than 7 million hectares of rice land – predominantly inhabited by impoverished communities with fewer opportunities for food security and livelihood options – is adversely affected by salt stress.

Timeframes for implementation

The use of off-season nurseries, multi-location testing networks and new breeding technology has the potential to drastically reduce breeding cycle times by almost two-thirds (Atlin et al. 2017). New varieties can now be developed and released within 5-7 years. Whilst such advances in breeding technologies and registration policies have significantly reduced the time taken to develop and commercialize stress-tolerant varieties (e.g. Reynolds and Langridge 2016; Grüneberg et al. 2015) in country policies also need to be addressed to accelerate adoption of new technologies where needed.

Monitoring and evaluation

The benefits of stress tolerant varieties impact positively on the adaptation (increasing resilience) pillar of the global stocktake. Process indicators (e.g. # of beneficiaries accessing/adopting improved varieties) can be measured using household level surveys, especially nationally representative sample surveys for agriculture. Outcome indicators (e.g. positive changes in households food and livelihoods security, income diversification, ability to recover from/buffer against climate-related shock, or increases in household saving/investment capacities) can also be measured using household-level surveys, and will enable the assessment of adaptation benefits in terms of decreased vulnerability/increased stability and/or improved adaptive capacity. At a more fine-tuned level, adaptation co-benefits at the farm level can be evaluated using more technical quantitative indicators to measure improved productivity, positive changes in soil characteristics and resource use efficiency (e.g. water, fertilizers) as well as potential co-benefits in GHG emissions reductions and/or carbon sequestration per hectare covered (e.g. improved pastures).

Challenges

Two of the main challenges of implementing this intervention have been related to slow varietal replacement, particularly in SSA. Although the time taken to register new varieties has reduced in many countries, older varieties remain available on the market for many years. In the USA varieties are available to farmers for 4-5 years before they are replaced by superior ones (Magnier et al. 2010). By sharp contrast, in SSA, maize varieties are often 20-

30 years old meaning they were developed in significantly different climate (Atlin et al. 2017).

Another challenge is the massive range of farm environments that exist, and the need to be able to tailor not only new varieties but also the seed systems and crop management practices that complement them. One solution is to develop better global networks in collaboration with national programs and other entities so that data and other resources can be shared, and lessons learned in one environment or cropping system can be applied to others (Reynolds et al. 2017). If at the same time, the political and institutional bottlenecks – including restrictive seed policies, limited number of seed producers, poor marketing and distribution - that restrict smallholder farmer access to new seed can be addressed then the challenges of crop improvement could be tackled more systematically.

Key resources

Maize variety options of 13 African countries:

Abate T. 2016. *Maize Variety Options for Africa*. Nairobi: Drought Tolerant Maize for Africa. Available online at: http://repository.cimmyt.org/xmlui/bitstream/handle/10883/16772/58500.pdf

Global use of improved wheat varieties:

Lantican MA, Payne TS, Sonder K, Singh R, van Ginkel M, Baum M, Braun HJ, Erenstein O. 2016. Impacts of International Wheat Improvement Research in the World 1994-2014. Mexico City, Mexico: International Maize and Wheat Improvement Center. Available online at: http://wheat.org/wheat-global-impacts-1994-2014-published-report-available/

CIMMYT International Maize and Wheat Improvement Center

CIP International Potato Center A CGIAR Research Center

IRRI International Rice Research Institute

CGIAR Research Program on Rice

CGIAR Research Program on Wheat

CGIAR Research Program on Maize

4. Improving smallholder dairy – enhanced incomes and greater climate resilience

The livestock sector is growing rapidly throughout the developing world in response to population growth, income increases and shifting consumption patterns (Thornton 2010). While much of the growth in meat production revolved around poultry and pig production in East Asia (Thornton 2010), livestock is a key economic growth priority in many other regions. In East Africa, and elsewhere, there are significant opportunities to enhance dairy production (Makoni et al. 2014). However, climate change impacts threaten livestock production, including through reduction in the quantity and quality of forage available in some regions and increased heat stress in animals. Changes to weather patterns, temperature increase, and increased incidence of extreme weather events, may also contribute to the spread of vector-borne diseases and macro-parasites, together with the emergence and circulation of new diseases. Therefore, efforts to enhance the resilience of the sector to climate shocks, with the side benefit of reducing GHG emissions intensities (as long as productivity is increased or maintained), are considered a promising innovation. Interventions could include improved feed and forage management, breeding for heat tolerance, and efforts to improve animal health. An example of a sector development programme endeavouring to realize climate benefits is shown in Case study 4.

Case study 4: East Africa Dairy Development (EADD) project mainstreaming climate actions

A large proportion of household income in mixed farming households in Kenya, Rwanda and Tanzania, is derived from dairy. In spite of the importance of dairy cows to households, the sector is unable to realize its full potential due to the lack of optimal production technology, access to inputs and business skills. Furthermore, climatic stresses, small plot sizes and low fertility soils cause food insecurity for both people and their livestock, necessitating a more resilient dairy production chain. The dairy value chain has therefore been a priority for livestock development actors for over a decade. One example of a promising project is the East Africa Dairy Development (EADD) project, launched in 2008 in a partnership between Heifer International, ICRAF, ILRI, TechnoServe and African Breeding Systems, funded by the Bill and Melinda Gates Foundation. EADD focused on developing the livestock sector in the East African region, by providing better business delivery services, chilling and processing, and production inputs and market access through local business hubs. The programme covered 179,000 smallholder families in its first phase. Now, in its second phase which started in 2014, the programme will work with an additional 136,000 smallholder families, and has adopted climate-smart agriculture as an overarching objective, primarily focusing on reducing GHG emissions intensities through improving livestock productivity.

Adaptation benefits

Future climate change will affect both the availability (through more seasonal variability) and quality (this will decrease) of the whole range of feed resources (Thornton et al. 2015), so work on adapting feeds and forages to climate change is a priority. Currently, many dairy smallholders rely on grazing to feed their livestock, but while this feed method has a low cost, it is vulnerable to seasonal weather patterns (EADD 2009). Having multiple sources of livestock feed through fodder source diversification helps improve livestock system resilience, as, for example, almost all dairy farmers in East Africa require supplemental sources of feed during the dry seasons. Introducing improved fodder species (both grasses and trees) can help diversify the fodder source, and also helps stabilize ecosystem services, improving the soil's ability to retain water and thereby be more resilient to dry periods.

In mixed crop-livestock systems, risk can sometimes be ameliorated via the addition and/or substitution of crop and livestock species and breeds that are more tolerant of heat or drought, and ILRI has documented successes in using community-based breeding programs to encourage better herd and breed management (Atakos 2016). Finally, increasing incomes also improves resilience to climate shocks, as households can use cash to purchase feeds or animal health services to offset the impact of climate shocks, or they can invest in other types of production.

Co-benefits

Interventions to make the livestock sector more resilient can deliver positive co-benefits for low carbon development. For example interventions related to feed improvement can reduce emissions per kilogram of meat and milk. Improved grazing management can increase carbon sequestration in the soil and manure management efforts also reduce emissions from the sector. A resilient and vibrant livestock sector will also contribute to nutrition outcomes.

Costs and benefits

Encouraging dairy farmers to invest more in improved feed resources is constrained by the low returns many receive from their small numbers of low productivity animals, and the relatively high cost of purchased feeds and labour required to manage planted fodders. This is why the EADD and other similar projects focus on both productivity improvements and collective marketing arrangements. Such a holistic approach can deliver positive benefits for communities, for example, Phase I of EADD earned its 179,000 beneficiaries more than USD 131 million, while saving USD 11 million on financial services (Heifer International 2014).

Geographies

The interventions proposed here apply to East and Southern Africa, with some applicability to West Africa.

Timeframes for implementation

The timeframe for implementing interventions in the livestock sector vary. For example, efforts to improve feed and forage management, breeding for heat tolerance, and efforts to improve animal health have varying time scales. The approaches and technologies for improving feed and forage management are largely known, but require participatory work with farmers to understand their needs and constraints (e.g. www.ilri.org/feast), time frames vary from six months to a year. The time frame for breeding is considerably longer; community-based breeding programs require 2 years minimum to train farmers to select for better adapted animals/ avoid negative selection. Efforts to improve animal health also vary: disease surveillance programs require one to two years to establish and sustain. Integrating private- public health service providers into disease surveillance to make health inputs more readily available takes 6 months to a year.

Monitoring and evaluation

Monitoring the benefits of improving smallholder dairy and livestock production, breeding for heat tolerance, feed and forage management, can help countries report progress against their climate goals in the UNFCCC's global stocktakes. Countries' state of implementation progress and desirable outcomes can be monitored and evaluated through key indicators that can be incorporated in monitoring and evaluation (M&E) procedures across different scales going from national/sub-national or landscapes to households or farms.

Field-based household level surveys designed to monitor process indicators will allow to track actual # of beneficiaries trained for and/or adopting improved dairy/livestock production-related practices, whereas outcome indicators will enable to assess their adaptation benefits in terms of decreased vulnerability/increased stability and/or improved adaptive capacity (e.g. positive changes in households livelihoods security: income stability, fodder source diversification, ability to recover from/buffer against climate-related shock like droughts, or increases in household saving/investment capacities). At a more fine-tuned level, adaptation co-benefits at the farm level can be evaluated using more technical quantitative indicators to measure improved productivity, positive changes in feed/forages nutritional characteristics, resource use efficiency over time as well as potential benefits in GHG emissions reductions and/or carbon sequestration per production unit. Monitoring mitigation benefits of improvements in smallholder dairy systems requires adopting a dynamic Tier 2 methodology (per Intergovernmental Panel on Climate Change (IPCC) guidelines), which is able to capture the GHG effects of productivity improvements. This requires more detailed data on livestock population structure, management, and feeding conditions. Close collaboration between agencies involved in M&E of adaptation and mitigation action and agricultural statistics agencies is key. Because livestock projects are often implemented by or with the private sector, embedding M&E of mitigation actions in existing data systems (e.g. at milk collection and processing centres) can reduce cost.

Challenges in implementation

Livestock are a key asset that many households rely on in response to shocks, particularly climatic shocks. Thus interventions to protect them are worth the investment. With respect to the interventions mentioned here, access to health services requires greater public and private partnership, along with awareness raising and improved access to high quality drugs and vaccines. In terms of improved breeding, the main challenge is reliability of artificial insemination services, and low awareness about techniques for improved local breeding management. Finally and perhaps most difficult, the feed and fodder value chain is underdeveloped, limiting many smallholder farmers access to these inputs, and keeping costs such as transport high. Small land size also constrains farmers' ability to grow fodder crops, which may compete with food crops, unless fodder production is regarded as a profitable activity (as for example in Ethiopia, India and West Africa).

Key resources

<u>Adaptation in livestock farming systems in sub-Saharan Africa:</u>

Thornton PK, Herrero M. 2015. Adapting to climate change in the mixed crop and livestock farming systems in sub-Saharan Africa. *Nature Climate Change* 5:830-836. Available online at: http://go.nature.com/2lyA4iT

<u>Climate-smart livestock sector development:</u>

FAO. 2013. *CSA Sourcebook Module 8: Climate-smart Livestock.* Rome, Italy: FAO. Available online at: http://www.fao.org/docrep/018/i3325e/i3325e.pdf

Climate-smart livestock sector development in NAMAs:

van Dijk S, Tennigkeit T, Wilkes A. 2015. *Climate-smart livestock sector development: the state of play in NAMA development.* CCAFS Working Paper No. 105. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: https://cgspace.cgiar.org/rest/bitstreams/46884/retrieve

5. Alternate wetting and drying in rice systems

Alternate wetting and drying (AWD) was originally developed as a water-saving strategy in rice production. With growing water stress, the practice helps rice farmers become more resilient and reduces emissions. AWD is suitable for irrigated rice systems and involves periodic drying of the field by suspending irrigation for several days. Fields are irrigated again once the first small soil cracks are visible so that there will be sufficient water available for the rice plants (IRRI 2009). This practice has been applied successfully in several rice growing countries, but the key for wide-scale adoption of this technique is convincing the various stakeholders – from farmers to policy makers – of the multiple benefits of this practice. Those benefits arise from saving of pumping costs, reducing drought impacts, reducing emissions and better plant performance. At this point, AWD is at the core of mitigation efforts and National Appropriate Mitigation Actions (NAMA) programs in the agriculture sector of effectively all rice-growing countries. The International Rice Research Institute (IRRI) is involved in various forms in these developments, namely by conducting upscaling projects in Bangladesh and Vietnam as well participating in the planning phase of NAMA activities in Thailand. AWD has potential to be expanded to areas in Africa where paddy rice is grown or being planned.

Case study 5: Alternate wetting and drying in the Angat-Maasim River Irrigation System, Philippines

The Angat-Maasim River Irrigation System (AMRIS) encompasses ca. 26,800 ha of rice area in two provinces of the Philippines. The water reservoir (Angat reservoir) supplies irrigation water for AMRIS but also supplies water for domestic use to Metro Manila. Until the 1980s the greater share of water has been used for agricultural irrigation. This trend has switched during the 1990s and early 2000s with now the bigger share of water being directed to Metro Manila. Particularly in water-scarce years, e.g. El Niño years, AMRIS has been facing water shortages resulting in crop losses. Therefore, the demand for water-saving irrigation techniques in this area is high. In the AMRIS area, AWD has been introduced by IRRI and the Philippine Rice Research Institute (PhilRice) in two pilot sites (~1-3 ha each) in 2013. After positive results from the pilot sites in terms of GHG reduction and acceptance by farmers AWD has been further out-scaled in the area within a national agricultural development program (FSSP, Food Staples Sufficiency Program) with the main implementer PhilRice.

Adaptation benefits

Adaptation benefits are obvious under water scarcity, as AWD has been developed as a genuine water-saving technique. The water saving potential is 15-40%, so that drought impacts can be prevented or at least buffered in dry seasons and years. In some irrigation schemes, AWD facilitates a more equitable distribution of water resources to areas that typically suffer from water shortages. If the principles of 'safe' AWD are followed (i.e. threshold water level for re-irrigation ~15 cm below soil surface, standing water during flowering time) there will be no yield reduction. AWD is widely accepted as the best water management practice for irrigated rice and it is part of the recommendations of Good Agricultural Practices in several countries and also incorporated into the production standard of the Sustainable Rice Platform (SRP).

Co-benefits

AWD helps countries transition into low-carbon development pathways, while improving resource efficiency in the rice sector. AWD has one of the highest GHG mitigation potentials of all climate actions in the agriculture sector reaching from 30% to 70% of methane emissions under continuous flooding (Sander et al. 2015). It is also considered a sustainable practice under the SRP. The AWD practice also reduces uptake of arsenic in contaminated soils. Moreover, AWD maintains the wetland features of rice landscapes and has fairly limited impacts on the composition of flora and fauna in the fields. This is a fundamental difference to more drastic changes such as conversion of wetlands rice fields to upland farming e.g. switching to 'aerobic' rice or upland crops.

Costs and benefits

Profitability of AWD will largely vary in space and time. In pilot studies, farmers' income increased by 38% in Bangladesh where water is sourced from deep wells. In contrast, monetary benefits are lower in irrigation systems with river diversions, but even in southern Vietnam profitability increased by 17% based on 'with and without' AWD comparison (Lampayan et al. 2015). However, detailed cost-benefit analyses of AWD are still limited.

Geographies

AWD is a practice for irrigated rice environments. It has shown to be particularly successful when pumps are being used for irrigation because farmers experience a direct monetary benefit due to reduced pumping costs. AWD is not recommended in areas with potential salinity stress as reduced water input might aggravate the salinity level and cause yield decline. Several countries have identified AWD as a key climate action in their agriculture sector and plan to out-scale the technology in line with their Nationally Determined Contribution (NDC)s, namely Vietnam, Bangladesh and Thailand. IRRI has developed a GISbased methodology to assess climatic suitability for AWD on national scale (Sander et al. 2017). Heavy rainfall can impede application of AWD.

Timeframes for implementation

AWD can in most instances be adopted immediately. One challenge though is a change in perception and behaviour of rice farmers who traditionally grow rice in continuously flooded fields. Likewise, the staff of the irrigation agencies have to be convinced of benefits through AWD as their mandate is to provide sufficient water to all farmers.

Monitoring and evaluation

Monitoring the benefits of AWD can help countries report progress against their climate goals in the UNFCCC's global stocktakes. AWD implementation can be monitored in various forms. Field-based household level surveys designed to address process indicators can allow to track # of beneficiaries trained for and/or adopting AWD whereas outcome indicators will enable to assess their adaptation benefits in terms of decreased vulnerability (e.g. reduced frequency of drought impacts) increased stability and/or improved adaptive capacity (e.g. positive changes in households' livelihoods security: reduction in production costs, increased ability to buffer against droughts). At a more fine-tuned level, adaptation co-benefits at the farm level can be evaluated using more technical measures to quantify potential yield improvements, changes in water use efficiency over time as well as potential benefits in GHG emissions reductions per production unit/hectare covered. IRRI is currently pilot testing automated field water monitoring (AutoMon) with sensors equipped with a transmitting device which can send real-time field water data to farmers, pump owners, irrigation groups or local government units. With the expected drop in price for these sensors automated monitoring on large scale will become an option.

GHG emission savings can then be calculated using IPCC formulas or biogeochemical models. The approved CDM baseline methodology for rice production (SSC-NM063) requires farmer logbooks, but the reliability of this approach is at question. M&E procedures in the envisaged NAMA project in Thailand will rely on observations made by trained extension staff. Other projects are working with satellite observation for given areas, e.g. in northern Vietnam.

Challenges in implementation

Increasing weed pressure: Weed growth may increase under more aerobic conditions. This problem, however, can be minimized by proper water management, e.g. maintain continuous flooding for 3 weeks after crop establishment.

Required changes in behaviour/perception: Traditional rice farming practices often includes continuous flooding of rice fields. Extension services and farmer field schools will have to play a pivotal role in changing farmers' perception.

Unequal distribution of benefits: The most vulnerable farmers are located far from the irrigation source ('end of the pipe'). They don't receive sufficient water in drought years and in some cases even suffer in years with regular rainfall. AWD could technically improve their situation by relocating water savings from upstream to down-stream sections within a given scheme. On the other hand, farmers near the water sources will not experience immediate benefits for themselves after switching to AWD. In turn, upscaling approaches should not focus on farmers only, but should involve wider farmer groups, e.g. irrigation associations or cooperatives, as well as decision makers across scales.

Packaging with other technologies: AWD often provides only limited incentives as a stand-alone technology, but will be more attractive as integral part of innovative crop management packages to increase resources use efficiencies. Examples for these packages can be derived from technology campaigns in Vietnam (1 Must-do; 5 Reductions) as well as the SRP standard for sustainable rice production. Eventually, these packages lead to overall benefits that are sufficiently attractive to farmers to change conventional crop management practices.

Key resources

<u>Overview of AWD:</u>

[IRRI] International Rice Research Institute. 2009. *Saving water: alternate wetting and drying (AWD)*. IRRI Rice Fact Sheet. Los Baños, Philippines: International Rice Research Institute. Available online at: http://teca.fao.org/sites/default/files/technology_files/watermanagement_FSAWD3_0.pdf

Geographic suitability assessment of AWD:

Sander BO, Wassmann R, Palao LK, Nelson A. 2017. Climate-based suitability assessment for alternate wetting and drying water management in the Philippines: a novel approach for mapping methane mitigation potential in rice production. *Carbon Management* 8:1-12. Available online at:http://www.tandfonline.com/doi/full/10.1080/17583004.2017.1362945

Mitigation potential of AWD:

Sander BO, Wassmann R, Siopongco JDLC. 2015. *Mitigating greenhouse gas emissions from rice production through water-saving techniques: potential, adoption and empirical evidence.* In: Hoanh CT, Smakhtin V, Johnston T (eds). Climate change and agricultural water management in developing countries. CABI Climate Change Series. Wallingford, United Kingdom: CABI Publishers. p 193-207
Available online at: http://www.cabi.org/cabebooks/FullTextPDF/2015/20153417471.pdf

Economic assessment:

Lampayan RM, Rejesus RM, Singleton GR, Bouman BAM. 2015. Adoption and economics of alternate wetting and drying water management for irrigated lowland rice. *Field Crops Research* 170:95-108. Available online at:
http://www.sciencedirect.com/science/article/pii/S0378429014003001

CGIAR RESEARCH PROGRAM ON Rice

IRRI International Rice Research Institute

6. Solar irrigation entrepreneurs: expanding access to affordable irrigation and enhancing resilience

It is widely recognized that the provision of irrigation can help millions of smallholder farmers intensively cultivate their small parcels to improve income and better cope with climate induced uncertainties. This is particularly true for Africa and parts of South Asia where the fortunes of millions of poor farmers continue to depend heavily on rainfed agriculture. The challenge is to expand irrigation access to the largest number of poor while keeping its costs affordable, without threatening resource sustainability and minimizing its environmental footprint. The International Water Management Institute (IWMI)'s work in the eastern Gangetic basin in South Asia, home to a quarter of the world's poor, has shown that if promoted well, solar powered irrigation can be a key part of the solution.

Studies suggest that shallow and abundant aquifers of the lower Gangetic basin in Nepal Terai, eastern India and Bangladesh can easily support 2.5 crops/year without any threat of long-term depletion. Yet, cropping intensity in the region continues to range between 1.2 and 1.5 crops/year. This is partly due to extreme land fragmentation – which makes investing in wells difficult for marginal farmers – and to a large extent due to high-energy costs of pumping groundwater. As a result, the poor end up paying a third or more of their irrigated crop output as irrigation fee to diesel pump owners from whom they purchase irrigation service at a premium. Governments are well aware of this inequity but attempts to subsidize diesel for smallholder irrigation have been frustrated by leakages. Delivering subsidized farm power is not only costly but also has a long gestation period. In this context, the falling prices of solar technology in recent years have opened up a new and attractive possibility.

IWMI research shows that promoting small, individual, 1-2 kWp solar pumps is suboptimal; instead, 5-6 kWp solar pumps should be offered to enterprising young men and women as solar entrepreneurs to catalyse competitive and equitable irrigation service markets (Case study 6). A 1-2 kWp solar pump can operate at full power 3-4 hours daily and pumps little water in the morning and evening, meaning that such pumps are used as standby with the larger diesel or electric pumps remaining as the mainstay for irrigation. Instead, setting up 6-15 young entrepreneurial farmers as Solar Irrigation Service Providers in overlapping command areas will help: [a] create a competitive water market offering pump-less farmers irrigation service at affordable price; [b] create 6-15 full time jobs in every village; [c] crowd out diesel tubewells; [d] expand irrigated area; [e] promote intensification and diversification of farming systems; [f] improve utilization of solar pump capital; and [g] incentivize solar entrepreneurs to contribute to capital investment.

Case study 6: Piloting a solar irrigation entrepreneurship approach in Chakhaji village, Bihar, India

In 2016, the IWMI-Tata program, under CCAFS and WLE, partnered with Aga Khan Rural Support Program (AKRSP) to support 6 young farmers in Chakhaji village of Bihar, India to become service providers by offering 60% capital cost subsidy on 5 kWp solar pumps each with 1000 feet of buried pipe distribution (total cost: USD 49,600). The 40% contribution from the entrepreneurs is recovered through an upfront contribution and 4 annual instalments thereafter. The pumps are located so as to have over-lapping command to ensure that buyers could access irrigation from two or more service providers. The solar entrepreneurs benefit from free solar energy but are under pressure to generate cash for repaying instalments. This makes them aggressively seek buyers to maximize their water sales; in the process, they offer better irrigation service at lower prices.

The pilot has only completed one winter and one summer season; but evidence is already mounting that 30 kWp solar panels combined with buried pipe distribution will benefit the poor much more than giving 2 kWp solar pumps to 15 poor farmers. Before the pilot began, 18 diesel pump owners served 1,623 plots belonging to 403 smallholders. These have now been crowded out by new service providers. Before the pilot, diesel pump owners sold water at INR 120/hour; now solar pump suppliers sell water at INR 90/hour and finish watering a field in much shorter time. Earlier, only tubewell owners sowed rice pre-monsoon while buyers waited for rains; tubewell owners grew maize when buyers grew fodder. Now, buyers sow rice pre-monsoon and also grow maize and vegetables. Gross irrigated area in the village has increased by 40%. While service providers are increasing their revenues from larger sales, water buyers are capturing a larger share of the growing pie than they had ever enjoyed.

Adaptation Benefits

Solar irrigation promotion as described above can rapidly expand pro-poor irrigation access, secure farming against climate shocks, promote sustainable intensification and diversification, improve utilization factor of solar pump capital, and ensure food and livelihood security. In some locations, increased groundwater use will also ease surface flooding by allowing greater natural recharge.

Co-Benefits

In addition to quickly expanding quality irrigation to the poor at affordable cost, this approach also helps create full-time livelihoods for 6-15 young service providers per village and almost completely eliminate the carbon-footprint of fossil fuel-based groundwater irrigation.

Costs and benefits

Early evidence from the Chakhaji pilot in Bihar suggests that USD 49,600 invested in 6 solar pumps yielded the following economic benefits in the first winter and summer seasons: [a] saving 6,650 litres of diesel consumption valued at USD 6,650; [b] 3,325 hours of solar irrigation to provide 498 acre waterings valued at USD 3,836 and resulting in direct increase in net farm income of water buyers of USD 11,500 (not counting irrigation gains to service providers); and [c] reduced CO_2 emission to the tune of 18 t yr-^{1}. Assuming an average of 6 waterings per crop, Chakhaji pilot created irrigation potential at USD 1,754 ha^{-1}, a fraction of USD 10,000 ha-^{1} standard for public irrigation systems.

Geographies

This option described above is specifically tailor made for eastern Gangetic plains which have abundant groundwater resources, copious aquifers and an agrarian economy that relies heavily on diesel-powered shallow tubewell irrigation. The option is ideal for fragmented smallholder farms located in a contiguous area, facing high risk of crop loss from seasonal flooding and constrained by high irrigation costs. In our assessment, it is feasible under the present option to add 20 million hectares of high quality, affordable solar pump irrigation in the region within 5 years at costs much lower than through surface irrigation projects and with significantly more contribution from farmers. An outlay of USD 1.75 billion – of which, the solar entrepreneurs can contribute ~50% – can add a million hectares of irrigated area. Solar irrigation is also feasible in Africa, though would need to be tailored to the specific circumstances.

Timeframes for implementation

At current costs, and under the proposed model, we expect that entrepreneurs will be willing to contribute 40-45% of the capital costs. Fortunately, the unit price of solar technology has been rapidly declining over the past few years. This means that the capital subsidy can be eventually phased out provided accessible and effective financial products are developed to facilitate private investments.

Monitoring and evaluation

Monitoring the benefits of solar irrigation can help countries report progress against their climate goals in the UNFCCC's global stocktakes. Field-based household level surveys designed to address process indicators will allow to track actual # of beneficiaries accessing solar powered irrigation whereas outcome indicators will enable to assess their adaptation benefits in terms of food security (e.g. measured as households' food diversification and availability over critical periods), production intensification or livelihood security stability and enhanced adaptive capacity (e.g. changes in on-farm income, enhanced ability to buffer against drought, or increase household's saving/investment capacities). An effective measure of the income and livelihood impact would be the gross value of agricultural output – which, in the case of Chakhaji, we expect will more than double within 2 years. Another indication of how well the business model is performing would be private investments by entrepreneurs to extend their buried pipeline networks to capture greater market share. At a more fine-tuned level, adaptation and mitigation co-benefits at the farm level can be evaluated using quantitative indicators to measure improved yields and productivity, increase resource use efficiency/crop intensification and potential GHG emissions reductions.

Challenges in implementation

A key barrier to rapid scaling up the proposed approach is the current capital subsidy regime. The current model in India of offering 80-95% capital subsidy on small 1-2 kWp solar pumps imposes restrictions on expansion of the market and removes incentives to continuously improve product quality and lower product costs. With high capital subsidies and unit costs determined through a competitive bidding process, solar pump manufacturers have little or no incentive to innovate on product design. The goal of the profit-maximizing firm shifts from capturing the largest share of the market (by offering superior products at lower costs) to capturing the largest share of the government subsidy. This approach also often results in low consumer awareness, high consumer apathy and poor after sales service. The overall size of the market is determined not by the interplay of demand and supply but by government's provisioning of subsidy. Finally, the design tends to favour large, established players and discourages new entrants. The second key challenge to scaling would be the availability and accessibility of suitable loan products to encourage and facilitate private investments in solar-powered irrigation enterprises.

Key resources

Potential of solar-powered pump irrigation in India:

Shah T, Kishore A. 2012. *Solar-powered pump irrigation and India's groundwater economy: A preliminary discussion of opportunities and threats*. Water Policy Highlight #26. Anand, Inda: IWMI-Tata Water Policy Program.
Available online at: https://iwmi-tata.blogspot.in/2012/11/2012-highlight-26.html

An action agenda for water management in India:

Shah T, Verma S. 2014. Addressing Water Management. In: Debroy B, Tellis AJ (eds). *Getting India back on track: An action agenda for post-election reforms.* Washington, D.C.: Carnegie Endowment for International Peace. p 185-205.

IWMI International Water Management Institute

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

AKRSP

7. Digital agriculture – from tailored advise to shared value with millions of farmers

Digital agriculture encompasses an array of technologies, channels, and analytic capabilities that are being applied to make farming more precise, productive, and profitable. These technologies tend to be applied with the goal of increasing productivity per unit of land, and they can be a natural complement to climate services and other services offered through digital platforms (e.g. insurance, credit).

Climate change adaptation is knowledge intensive, and successful efforts could benefit from more effectively harnessing the power of data. For example, forecasts can be combined with agricultural models and other data sources to provide farmers with much more dynamic advisories of what to plant and when and how to plant it. Adaptation can also be highly site specific, and data and information services enable tailoring of recommendations to specific farms and farmers, increasing the relevance of the advice and the likelihood of it being put into action. Integrating more data and digital tools into agriculture to boost productivity has a number of potential ancillary benefits: greater efficiency in use of inputs can increase the value derived from farming a unit of land, reducing incentives to convert more land to agriculture (a key driver of GHG on a global scale); the data generated in service of productivity can be used for analysis and sustainability planning at a landscape or system-level; and digitization enables new linkages with markets that can help improve value chain coordination and reduce post-harvest loss.

There is a growing body of evidence showing that digital channels such as Short Messaging Services (SMS), Interactive Voice Response, low-cost video, and digitally-delivered financial services are creating true interactivity directly with small-scale farmers in ways that were not possible just a few years ago (see Case study 7). These channels, increasingly combined with powerful analytics, are a feature of new digital business models that are creating new ways of managing risk and can facilitate adaptation on a landscape or even farming-system scale.

Case study 7: Towards digital agriculture in Zimbabwe

Econet Wireless, Zimbabwe’s largest telecommunications company, is spurring a data revolution in the country’s agriculture sector. The company offers, among other things, network connections, mobile banking, and the EcoFarmer mobile platform. EcoFarmer provides farmers with membership of the Zimbabwe Farmers’ Union, as well as crop and livestock farming tips, index-based crop insurance, and funeral insurance coverage, all at USD 1 per month and accessible through a basic mobile handset. Currently over 700,000 farmers are registered for EcoFarmer, but Econet is expanding its service offerings to include ‘Dial-a-Mudhumeni’ (for agricultural advice) and to give farmers access to loans.

Adaptation benefits

Digitization of farming systems, based on true interactivity with farmers over digital channels, is on the path to becoming critical for adaptation. The precise management of production factors made possible by digital technologies can improve the cost-efficiency of input use while helping to boost productivity per unit of land. Big data, generated in the pursuit of farming intensification on individual farms, can enable analyses on a larger scale that can inform adaptation planning across landscapes or regions. For example, researchers at the International Center for Tropical Agriculture (CIAT) were able to use data from the national meteorological service and several thousand farmers' crops to generate in-season guidance on planting times, with an impact in the tonnes per hectare (CIAT 2014).

Combining climate information with good quality, site-specific data on factors such as on soil fertility and erosion risk enables implementers to make decisions which take into account the sustainable productive potential of land in the near and long term. Such an approach begins to set some bounds around the array of sustainable farming choices that may be made today, and these can be selected in light of human (e.g. farmer preference) and market incentives. For digitally enabled farming adaptation to reach its full potential, research-driven insights on land use and the impact of farming systems needs to be more fully bridged with digital channels for interacting with farmers.

Co-benefits

Data-driven farming generates new site-specific intelligence that should enrich long-term sustainability planning and equip farmers with more tools to adapt to climatic shocks or dramatic market shifts, while more efficient input use matched to climatic trends can help reduce their carbon footprint. In some systems, the increased data has highlighted the benefits of mixed cropping and agroforestry systems in terms of sustained productivity, which on a farm scale may make improved incomes and nutrition, and on a landscape scale may help with biodiversity and mitigation.

Costs and benefits

The array of technologies, digital channels, and analytic capabilities comprising digital agriculture have different costs and benefits according to their context and the scale at which they are used. For example, remote sensing analytics is being used with increasing precision to predict crop yields, improving in-season management decisions, yet for many users or crops the costs of high-resolution imagery required to do this analysis may still be prohibitive. Similarly, many of the precision agriculture software and hardware products on the market today favour very large farms or very high-value crops.

New digital channels have dramatically changed the cost-benefit of reaching farmers at scale. Even where willingness to pay may be low, the increased access to agronomic advise can result in higher productivity, which creates incentives for other actors (input dealers, agribusinesses, non-profits) to develop digital business models that capture some of this value of advice and subsidize access to the advice for small-scale farmers. There are some early stage successes (such as One Acre Fund in East Africa, or MyAgro in Mali) where bundling digital financial services and farming advice has impacted both farmer productivity and overall business growth (see also Case study 7). Such models can become critical infrastructure for adaptation.

Geographies

These tools and technologies can work in virtually any geography or agro-ecological zone where there is cost-benefit to be gained. As a result, the most promising countries tend to be those with an effervescent digital economy overall characterized by: good rates of mobile telephony and data penetration, competitive markets for broadband connectivity, enabling regulations for mobile financial service provision, and a diversity of actors in the digital marketplace such as startups, value-added service providers, software companies, business process outsourcing firms, etc. The mobile telephony industry association GSMA estimates that by 2020 an additional 350 million rural farmers will have access to mobile phones, and revenue opportunities in machine-to-machine ('Internet of things') communications will grow over USD 530 Million, and estimates that electronic payments related to agriculture value added services will grow over USD 2 Billion worldwide (GSMA 2017).

Timeframes for implementation

The shortest route to implementing digital agriculture approaches would be to leverage the digital economy of the country where one seeks to do so. There are, for example, many providers of digital channels for interacting directly with farmers that are active in emerging economies. Some concerted effort on integrating digital channels with existing climate services and deeper analytics will be required, but this should be a question of months – not years – of applied effort by a team of data system technicians in many country environments around the world, ideally in the context of an alliance with a provider (e.g. a mobile network operator or value-added service provider) that has an interest in taking a solution to scale.

Monitoring and evaluation

Monitoring the benefits of digital agriculture technologies might help countries report progress against their climate goals in the UNFCCC's global stocktakes. Field-based household level surveys designed to address process indicators will allow to track actual # of beneficiaries accessing or adopting digital agriculture technologies whereas outcome indicators will enable to assess their adaptation benefits in terms of decreased vulnerability, increased productivity per unit of land, improved incomes stability and nutrition and/or improved adaptive capacity (e.g. positive changes in households' livelihoods, diet, ability to prevent, buffer or recover from climate-related shocks or increases in household saving/investment capacities). In addition, digital technologies can themselves be useful tools for monitoring process and outcome indicators. At a project or enterprise level, one common approach to evaluating the effectiveness of digital channels is to quantify the value of agronomic advice in terms of end-of-season yields and compare it with costs of delivery and customer willingness to pay.

Challenges in implementation

Good quality data: Access to good quality data from providers of climate services and from farm locations themselves is probably the greatest barrier to applying digital agriculture – without these data, the model outputs will not achieve the utility and site-specificity of farming advice that is needed to foster sustainable intensive production.

Strategic inertia: Agriculture system actors may have little experience leveraging the richness of the digital economy in their countries; they may simply not be in habit of it. On the other hand, digital service providers may need to be aided to target agriculture as opposed to more digitized sectors where they may perceive more market opportunity. Implementers can begin to overcome these challenges by fully leveraging services already existing in the marketplace in many countries around the world and by seeking to de-risk the entry of these providers into the agriculture sector such as through innovation processes, performance-based grants, or direct contracting.

Limited connectivity: The vast majority of smallholder farmers live in remote areas, where good, fast internet connectivity reaches less than 30% of the population (WEF 2017). Women constitute almost half of the agricultural labour force in developing countries, yet they are less likely to own a mobile phone though focused product design efforts can aid towards parity (GSMA 2015).

Key resources

<u>Evidence from the adoption of agricultural practices</u>

Cole S, Fernando A. 2014. *The Value of Advice: Evidence from the Adoption of Agricultural Practices.* Harvard University Press. Available online at: http://scholar.harvard.edu/files/nileshf/files/ao_paper.pdf

<u>Review of Big Data in smart farming</u>

Wolfert S, Ge L, Verdouw C, Bogaardt MJ. 2017. Big Data in Smart Farming–A review. *Agricultural Systems.* 153:69-80. Available online at: http://www.sciencedirect.com/science/article/pii/S0308521X16303754

CGIAR Platform for Big Data in Agriculture

CIAT International Center for Tropical Agriculture Since 1967 Science to cultivate change

8. Climate-informed advisories to enhance production and resilience

Climate services involve the generation, translation, communication and use of climate knowledge and information in climate-informed decision making, policy and planning (http://www.climate-services.org/content/what-are-climate-services). By reducing uncertainty, climate information (historical, monitored, predicted) and advisories enable farmers to better anticipate and manage adverse climatic conditions, take advantage of favorable conditions, and adapt to change. Yet a substantial body of research also shows that the availability of information is not sufficient for smallholder farmers to benefit. It must be supported by translation of climate information into actionable advisories and decision support, effective communication processes, investment in the capacity of farmers and other agricultural decision makers to understand and use the information, and enabling institutional arrangements and policies.

Developing effective rural climate information and advisory often requires substantial investment in institutional capacity. National Meteorological Services (NMS) may need innovation and investment in capacity to provide locally relevant information tailored to the needs of farmers. Climate research is expanding options for filling data gaps, generating relevant information without overextending NMS human resources. National Agricultural Research and Extension Systems (NARES) need innovation and investment in capacity to translate climate information into decision-relevant products and advisories, and to communicate information in a manner that builds the capacity of farming communities to understand and act on climate information. ICT and mass media are effective for short-lead weather information and advisories, while innovations in structured participatory processes have proven more effective at enabling farmers to understand and act on inherently probabilistic information at a climate variability time scale. Sustainable co-development of climate services between meteorological and agricultural institutions requires attention to institutional and governance arrangements – an emerging area of research, and a major focus of a national climate service framework process designed and supported by the UN Global Framework for Climate Services.

There have been some major breakthroughs in the delivery of climate information to farmers. India provides weather-related advisories to tens of millions of farmers through a variety of communication channels. In Senegal, climate information reaches an estimated 7 million farmers through rural radio. In Rwanda, agricultural extension staff and farmer volunteers are trained to access high-resolution climate information, and communicate it with groups of farmers (Case study 8). In Colombia, producer associations have learned to produce downscaled climate information, which a network of agro-advisory groups translates into management advisories and distributes to member farmers.

Case study 8: Scaling up climate information and advisory services for agriculture in Rwanda

"Rwanda Climate Services for Agriculture" funded by USAID and led by CCAFS and partners, aims to support transformation of Rwanda's farming communities and economy through climate services and improved risk management. It is developing the capacity of the Rwanda Meteorological Agency to provide high-resolution climate information (historic, monitored and predicted) tailored to the needs of agriculture, through online 'Maprooms'. Capacity to use climate services to manage risk is being enhanced through joint tool development with government agencies, and through training for agricultural extension personnel and other intermediaries. A national climate services governance framework and action plan will ensure sustainability. By September 2017, mid-way through the 4-year project, trained agricultural extension staff and volunteer Farmer Promoters had facilitated 50,000 farmers in 14 of the country's 30 districts to assess and adjust their farming and livelihood strategies based on climate information.

Adaptation benefits

Understanding the trends and variability associated with local climate is foundational for any efforts in adaptation. Effective use of relevant climate information, incorporated into agricultural advisory services, contributes to the resilience of rural communities in risk prone regions, enabling them to better understand the variability, trends and resulting risks that characterize their local climate; and to anticipate and prepare for both climatically favorable seasons and adverse conditions. Since climate services can guide the development, targeting and management of production technologies; and support more effective management of risks that impede the transition toward more productive and resilient livelihoods, effective climate services are part of the enabling environment for the transition toward more climate-smart agricultural systems.

Co-benefits

By better matching use of fertilizer and other production inputs to year-to-year climatic conditions, climate services can help countries in transitioning to resource efficient and low carbon approaches by supporting more efficient use of nitrogen fertilizers.

Costs and benefits

The benefits of climate-informed agricultural advisory services are expected to vary considerably by country and context. Available contingent valuation studies in Africa show that a majority of farmers would be willing to pay for the services, with annual amounts (averaged by study) ranging from about USD 1-20 per farmer. An economic equilibrium modeling study – covering a subset of available climate information and climate-sensitive farm decisions – estimated that widespread use of seasonal climate forecasts by farmers could contribute about USD 113 million annually to the economies of five eastern and southern African countries (Kenya, Malawi, Mozambique, Tanzania, and Zambia).

Geographies

Weather and climate information are expected to contribute to agricultural adaptation and to the resilience of rural communities across regions, but the greatest benefits can be expected in regions where climatic risk is most constraining, such as rainfed farming systems in sub-humid to semi-arid zones. The types and time-scales of information that are needed depend on the climate-related risks that impact agriculture, and the climate-sensitive decision options that are available to farmers and the institutions that serve them.

Timeframes for implementation

The time frame and financial resources needed to develop effective climate-informed agricultural advisory services in a given country depend on what is already in place in terms of: (a) the existing capacity of NMS to provide historical and forecast climate information tailored to the needs of the agriculture sector, (b) the existing capacity of NARES to translate and communicate climate information into actionable advisories, and (c) the partnership between NARES and NMS. Where NMS and NARES are reasonably strong, a well-designed project of at least 3-4 years can substantially improve their capacity to collective provide useful climate-informed advisories for farmers and other agricultural decision makers.

Monitoring and evaluation

The benefits of climate-informed advisories directly impact the adaptation (resilience) pillar of the global stocktake. Process indicators (e.g. # farmers accessing climate information and advisories, # farmers participating in training), measured through household surveys or training records, quantify the numbers and types of beneficiaries who access and use the services. Outcome indicators used to assess adaptation benefits in terms of improved livelihood security (e.g. # farmers perceiving improved farm productivity and income stability, estimated increase in production or income, value estimated by willingness to pay) and improved adaptive capacity (e.g. # farmers who adjust management decisions in response to information and advisories, # of farmers perceiving increased ability to manage climate risk) can be measured through household surveys, and contingent valuation methods. Process and Outcome evaluation must take into account the difficulty in isolating a 'control' group from access to information, and the possibility that use and adaptation benefits from climate information may vary considerably from year to year. It should be noted that the value of climate information results from how agricultural production systems and markets are managed, and therefore cannot be assessed independently of the broader agricultural environment and development strategy.

Challenges in implementation

Efforts to implement climate services that benefit farmers, at scale, often encounter several challenges including: (a) gaps in capacity of farmers and other agricultural decision makers to access, understand, and act on the information; (b) gaps in the capacity of NMS to provide actionable information; (c) gaps in historic meteorological records; (d) gaps in translation of climate information into agriculturally relevant information and advisories; and (e) gaps in the institutional and governance arrangements needed to sustain co-development of climate services particularly after the conclusion of a project. Well-structured participatory communication processes, which have proven to be effective in enabling farmers to understand and act on climate information, can be mainstreamed into the work of agricultural extension services and other farmer intermediaries through short-term training. An expanding suite of tools and methods are available to fill data gaps (by merging station observations with satellite and other proxy data), automate the production of historic and forecast climate information products tailored to the needs of the agriculture sector, and translate climate information into agricultural impacts and management options. The World Meteorological Organization (WMO)-led UN Global Framework for Climate Services (GFCS) offers guidelines and technical support for the development of national institutional and policy frameworks, and action plans for climate services.

Key resources

Case studies in Africa and South Asia:

Tall A, Hansen J, Jay A, Campbell B, Kinyangi J, Aggarwal PK, Zougmoré R. 2014. *Scaling up climate services for farmers: Mission Possible. Learning from good practice in Africa and South Asia*. CCAFS Report No. 13. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://cgspace.cgiar.org/handle/10568/42445

Participatory climate services field manual:

Dorward P, Clarkson G, Stern R. 2015. *Participatory Integrated Climate Services for Agriculture (PICSA): Field Manual.* Reading, United Kingdom: Walker Institute, University of Reading. Available online at: http://hdl.handle.net/10568/68687

Economic assessment:

Anderson G, Kootval H, Kull D (eds). 2015. *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services.* Geneva, Switzerland: World Meteorological Organization. Online: http://www.wmo.int/pages/prog/amp/pwsp/documents/wmo_1153_en.pdf

Climate services to scale-out CSA:

Loboguerrero Rodriguez AM, Hansen J, Baethgen WE, Martinez Baron D. 2017. Climate services and insurance: scaling climate smart agriculture. *Agriculture for Development* 30:31-34. Available online at: http://hdl.handle.net/10568/81377

IRI International Research Institute for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY

9. Weather index-based agricultural insurance for countries and farmers

Erratic weather and extreme climate events erode farmers' livelihoods through loss of productive assets, while the uncertainty associated with climate variability is a disincentive to investing in agricultural innovation. Climate-related risk, thus, contribute to poverty traps, impeding the kinds of transformation that smallholder agriculture needs in order to adapt to climate change. Risk-reduction through insurance can play a part in stimulating the entrepreneurship and innovation needed for agricultural development. Agricultural insurance normally relies on direct measurement of the damage that each farmer suffers. Field loss assessment is costly and time consuming, particularly where there are a large number of dispersed farmers who can ill afford the inevitable delay in payments. Index-based insurance, on the other hand, is a feasible alternative. Payouts are triggered not by observed crop losses, but rather when an index – such as rainfall or average yield – falls above or below a pre-specified threshold. Insurers can automate payouts and make them quickly. This lowers administrative costs and premiums compared with conventional crop insurance. Individual farmers can purchase insurance or groups, such as a cooperative or microfinance institution, or a national government can also purchase the insurance for farmers (IRI 2013). IFAD, (2011) provides practical details on the design of weather-based index insurance indices.

Case study 9: East Africa and Agriculture and Climate Risk Enterprise (ACRE)

ACRE (Agriculture and Climate Risk Enterprise) is the largest index insurance program in the developing world in which farmers pay a market premium, and the largest agricultural insurance program in sub-Saharan Africa. ACRE acts as an intermediary between insurance companies, reinsurers and distribution channels/aggregators (e.g. microfinance institutions, agribusiness and agricultural input suppliers). ACRE's offers a wide range of products. These include insurance linked to agricultural credit from Micro-Finance Institutions (MFIs), and a product that links insurance to a replanting guarantee by a seed company. The insurance premium is incorporated into the price of a bag of maize seed. Each bag contains a scratch card with a code that is texted to ACRE at planting time to start coverage against drought. Each farm is monitored using satellite imagery for 21 days. If the index is triggered, farmers are automatically paid via M-Pesa mobile phone platform. The indexes that ACRE uses for its insurance projects are based on several data sources including solar powered automated weather stations, satellite rainfall measurements, and government area yield statistics. ACRE has 200,000 farmer clients in Kenya, Tanzania and Rwanda. Insured farmers have invested 19% more in farm productivity, resulting in 16% more earnings compared to their uninsured neighbours.

Adaptation benefits

There is growing evidence that bundling index insurance with credit, climate-smart technologies and/or life insurance can make it a real value-adding proposition for farmers and increase farmer demand. Insurance can enhance farmers' willingness to invest in farm productivity by their knowing that the insurance will very likely pay out in the event of a climate shock. Insurance increases the confidence of credit providers to lend to smallholder farmers. Evaluation of the R4 Rural Resilience Initiative in Ethiopia showed that insurance allowed farmers to increase their savings, increase the number of draught animals, access more credit, and invest more in inputs such as fertilizers and improved seeds. Further evidence that index insurance enhances adoption of improved production technologies comes from evaluations and experimental studies with farmers in Bangladesh, India, Ghana, Mali, Senegal, Kenya and Zambia.

Co-benefits

It is suggested that insurance fosters significant private and social benefits, but more work is needed to document this. Mitigation benefits will depend on the degree to which insured farmers are able to invest in technologies and practices that enhance carbon sequestration and/or reduce greenhouse gas emissions.

Costs and benefits

Agricultural insurance, including index-based insurance, is subsidized in many countries. In some cases the subsidies are justified because of market failures and externalities that constrain the development of privately provided and unsubsidized insurance. In other cases the rationale behind providing subsidies is that it facilitates poorer farmers' access to insurance. Little is known, however, about the effectiveness of the insurance subsidies in achieving their intended purposes and whether the impacts justify their costs. There is a need for more evaluations and impact assessments of both subsidized and unsubsidized agricultural insurance programs (Global Index Insurance Facility 2017). Any insurance subsidy needs to be 'smart' in terms of being cost-effective in achieving its underlying purpose, and avoiding both disincentive problems also well as becoming a growing financial burden on the government.

Geographies

Insurance operates best where it forms part of an integrated approach to risk management, where constraints such as lack of access to finance, improved seed, inputs and markets can be addressed. Weather-based index insurance does not have universal application and it needs to be considered in context, through case-by-case evaluation (IFAD 2011). Weather-based index insurance is only appropriate if there is an obvious, easily measureable and quantifiable climate risk (e.g. a deficit in rainfall at the start of the season). Further, there needs to be a demonstrable benefit in buying insurance, which is one reason why insurance is often bundled with credit or inputs which can demonstrate productivity gains. However, the most likely target group will be emergent and commercial farmers, as it is unlikely that the majority of poor smallholders would directly purchase insurance on a sustained basis. Recent rapid scaling has been most successful in the following countries: India, China, Zambia, Kenya, Mexico, Brazil and Ethiopia, indicating it is relevant in diverse situations. This suggests that index insurance has the potential to benefit smallholder agriculture at a meaningful scale (Greatrex et al. 2015).

Timeframes for implementation

Since the late 1990s, index insurance feasibility studies and pilot projects are functioning in a wide variety of settings throughout the developing world. IFAD (2011) details the stages required in the establishment of an index-based insurance scheme, these include the i) initial idea; ii) analysis of the concept; iii) pre-feasibility assessment; iv) pilot implementation; v) analysis of the pilot; and vi) scaling of the project. The time frame for establishing an index-based insurance scheme will depend on the institutional capacity.

Monitoring and evaluation

The benefits of interventions targeting the promotion of weather index-based agricultural insurance directly impact the adaptation (resilience) pillar of the global stocktake.

Systematic monitoring and evaluation exercises are needed in order to assess potential technical and operational issues (e.g. price, delivery channels). Standard household level agricultural surveys designed to address process indicators could capture how many farmers are insured or would be willing to buy weather index-based insurance. More detailed studies using outcome indicators and addressing farmers' behavioural changes would enable to assess adaptation benefits in terms of improved agricultural productivity and livelihood security (e.g. # farmers perceiving improved farm productivity or increased income stability related to weather index-based agricultural insurance, # farmers receiving weather index-based insurance’s payouts) and would be required to assess how insurance is facilitating resilience building (e.g. # of farmers willing to invest in agricultural inputs, improved practices and technologies; # of farmers perceiving increased ability to manage or buffer against climate-related risks, or # of farmers accessing credit, # of farmers with increased saving/investment capacities).

Challenges in implementation

Data availability - A weather index by its very definition is not directly insuring a farmer’s loss. Farmers may receive a payout even when their crops survive, or they may experience losses when a payout is not triggered. The phenomenon is known as ‘basis risk’. An index must be robustly designed so that it protects a farmer against the targeted risk and correlates well with losses. Good weather and crop data are needed for this to occur.

Enhanced farmer understanding - Many farmers are not familiar with insurance practices. For index insurance to achieve scale, it needs to be appropriately targeted and marketed in a way that farmers understand. Of particular importance is enhanced farmer understanding of the basic concepts of insurance transactions, such as the claims process, and the specific features of index-based insurance so that farmers have realistic expectations regarding payouts.

Regulatory environment - Establishing a legal and regulatory environment for enforcing contracts that both buyer and seller can trust is a fundamental prerequisite for index insurance; this often requires public-private partnerships that bring together government, local insurers and international reinsurers (who primarily provide financial risk transfer capacity).

Key resources

Introduction:

[IRI] International Research Institute for Climate and Society. 2013. *Insurance innovations for development and adaptation: Frequently asked questions*. Palisades, New York, United States: International Research Institute for Climate and Society. Available online at: http://bit.ly/2z2mpnC

Issues and good practices:

Hazell PB, Sberro-Kessler R, Varangis P. 2017. *When and How Should Agricultural Insurance Be Subsidized? Issue and good practices.* Washington, D.C.: Global Index Insurance Facility, World Bank. Available online at: http://bit.ly/2xEX3e0

Case studies of index insurance for smallholder farmers:

Greatrex H, Hansen JW, Garvin S, Diro R, Blakeley S, Le Guen M, Rao KN, Osgood, DE. 2015. *Scaling up index insurance for smallholder farmers: Recent evidence and insights.* CCAFS Report No. 14. Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: http://bit.ly/2yhptz9

Technical guide:

IFAD. 2011. *Weather Index-Based Insurance in Agricultural Development.* Rome, Italy: IFAD. Available online at: http://bit.ly/29YQH2b

Guidance for development practitioners:

World Bank. 2011. *Weather Index Insurance for Agriculture: Guidance for Development Practitioners.* Agriculture and Rural Development Discussion Paper 50. Washington, D.C.: World Bank. Available online at: http://bit.ly/2gYGdDM

10. Scaling up financing for climate change adaptation in agriculture

The success of adaptation actions in agriculture rely not only on technological innovations, but supporting institutional, policy, and investment environments, which can help innovations reach scale rapidly. New, fit-for-purpose business and financial models are an area for innovation to support scaling up of proven technological innovations. Key areas of focus include:

Mobilizing private adaptation finance: Adaptation finance discussions have traditionally focused on public sector sources, however the private sector offers a huge opportunity for mobilizing adaptation finance and implementing priority actions, including in the agricultural sector. The recent Demystifying Adaptation Finance for the Private Sector report found that the private sector is investing substantially in adaptation and resilience, both as a response to challenges faced by companies (e.g. increasing resilience of supply chains), and also in new opportunities emerging as a result of climate change (e.g. water-efficient irrigation systems) (Druce et al. 2016).

Impact investment: Impact investors fund projects with social and environmental benefits, and can be an important source of funding for projects in the agriculture sector, considering the multiple benefits investments in the sector can realize. Impact investment can occur through several routes, utilizing both existing development finance sources (e.g. development finance institutions and foundations), and new more mainstream investment groups interested in achieving social and environmental benefits alongside financial returns. The impact investing universe is growing rapidly, and several have a dedicated focus to agriculture (e.g. Root Capital, Acumen, LGT Venture philanthropy, Vital Capital) (Drexler et al. 2013). Such funds often have specific sectors and locations which they focus on. The Althelia Ecosphere Fund and Moringa Fund are examples of impact investment funds of relevance to the agricultural sector.

Blended finance: Involves the strategic use of development finance and philanthropic funds to mobilize private sector capital that can accelerate investments in climate-resilient agriculture. Public capital is usually deployed through grants, low-cost debt, guarantees, etc. to incentivize and leverage private sector capital. This aims to mitigate early entrant costs or risks in a certain market, help rebalance risk-reward profiles for pioneering investments and attract significant new private capital that can be invested in high-impact areas and leverage additional private capital.

Blended finance is increasingly used to demonstrate the financial, social and environmental viability of a pioneer investment, before it can be financed in commercial terms. A large number of key development finance actors and philanthropic funders, such as donors, Multilateral Development Banks (MDBs) and some other key development finance institutions and foundations, are increasingly recognizing its potential and are scaling up efforts to blend their capital and attract significant new private capital flows. This is opening the space to develop innovative investment vehicles (that aim to meet the different risk-return profiles of a larger number of new investors) and new financial instruments specifically tailored for low carbon resilient agriculture investments.

Blended finance represents a promising opportunity to cover the much-needed climate finance gap, and adaptation finance gap. The World Bank is currently exploring the opportunity to blend climate finance with traditional agriculture and forestry finance. To date, smallholder farmers and small and medium sized enterprises (SMEs) face numerous constraints to access adequate and sufficient finance, and financial institutions traditionally shy away from lending to the agriculture sector due to perceived high risks and high transaction costs, among other reasons. Blending climate finance with agriculture finance can help address some of these challenges and attract new domestic and international sources of private capital to accelerate investments at scale in the agriculture sector. There are some promising blended finance models that are currently blending climate finance and agriculture/forestry finance (e.g. Unlocking Forest Finance, Strengthening Adaptation and Resilience to Climate Change in Kenya Plus - StARCK+) to rapidly scale up investments in the sector (Sadler et al. 2016; AgriFin 2017).

Mainstreaming climate-resilient practices into financial institutions and investors' operations: Climate change will affect assets and investments at all levels, and it is in the interest of financial institutions and investors to learn to assess and manage climate risks ahead of the curve and invest in new business opportunities. This has the potential to dramatically increase the volume of capital being deployed by investors and lenders to the agriculture sector, focusing specifically on prioritizing resilience reduction options. Farmers that employ sustainable agricultural practices should be considered more bankable, all other factors being equal. Financial institutions and investors need to integrate climate change considerations into their strategies, programs and operations as not only a mechanism to better assess and manage risks but also to leverage and catalyse new business opportunities that will open up as a result of climate change (Sullivan 2014). Such efforts are now being increasingly undertaken by all sort of financial institutions and investors, from international commercial banks (e.g. the Banking Environment Initiative) to international, bilateral, multilateral, regional and national development banks, and developed and developing country commercial financial institutions. For example, the Climate Action in Financial Institutions Initiative has 30 institutions committing to climate actions.

Adaptation benefits

Financing for climate actions in agriculture is still minimal (Sadler et al. 2016), and the business and financial models described here can significantly increase the amount of investment flows to the sector, delivering adaptation benefits from various technological innovations. Investment is needed to drive scaling up of all the innovations described in this paper – the adaptation benefits are thus vast, and described under all the other innovations.

Co-benefits

Business and financial models which invest in the agricultural sector has the potential to deliver co-benefits for sustainable development, as described under the different innovations covered in this paper. Lobell et al. (2013) found that the mitigation co-benefits from broad-based efforts to adaptation in agriculture are inexpensive, when compared to activities where the sole focus is mitigation in the sector.

Costs and benefits

Different investors look for different types of financial returns. Not all are only interested in maximizing profits, e.g. impact investors / blended finance providers may accept lower returns in exchange for a certain impact. Companies, and their investors, will consider on a case-by-case basis if and how a certain adaptation investment works for them. This will be linked to many factors, including the nature of the investor and the investee. For example, an investor that buys stocks may focus on short-term (quarterly) performance, or may take an activist stance on certain topics given an industry view or ethos. A majority shareholder in a private company may take a view that an adaptation investment builds long-term value and push for such investments to be made. Costs and benefits of pursuing different adaptation investments will thus differ by type of investor, and their engagement modality.

Geographies

The business and financial models described here can apply in most geographies, but tailored to the specific opportunities. They may vary in geographic scope. For example, impact investments and blended finance solutions are occurring at multiple levels (national/regional/global). Private sector financing for adaptation also occurs at multiple levels, but within the company's sphere of activities.

Timeframes for implementation

Business and financial models can be rapidly developed if good opportunities exist. Their delivery of benefits to stakeholders will be highly context-specific, depending on the commodities and value chains involved and the nature of the farming communities and systems.

Monitoring and evaluation

Monitoring of investment flows to activities that enhance resilience and/or deliver mitigation benefits, provide useful status of the intervention. Several organizations keep track of such flows, including the Climate Policy Initiative (CPI), the Organisation for Economic Co-operation and Development (OECD) and different multilateral development banks.

Challenges

A key challenge in implementing innovative business and financial models relates to inclusion. Business and financial models tend to benefit those smallholders with more resources rather than the poorest of the poor. In addition, there is a fear of early-stage projects and businesses – both by normal investors and by development funders and foundations, which limits the amount of 'risk absorbing' capital available. The hierarchy of fiduciary responsibility, competing priorities, cost and return structures also limit the ability of the wider financial system to prioritize environmental and social factors. Capacity constraints on the part of developers also limit their ability to engage with investors and leverage on available financial opportunities.

Resources

Guide to the role of climate finance in agriculture

Sadler MP, Millan Arredondo A, Swann SA, Vasileiou I, Baedeker T, Parizat R, Germer LA, Mikulcak F. 2016. Making climate finance work in agriculture. Washington DC, United States of America: World Bank Group. Available online at: http://bit.ly/2z0OJZT

Agricultural value chain financing

Havemann T. 2017. Value Chain Finance for Agricultural Climate Change Resilience. Wageningen, The Netherlands. The Technical Centre for Agricultural and Rural Cooperation. Available online at: https://www.clarmondial.com/wp-content/uploads/2017/04/CTA_Value_Chain.pdf

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Conclusions

The ten innovations presented in this paper show that the agriculture research for development community has a well-developed knowledge base which can help the sector step up to the challenges posed by climate change. In view of the triple challenge faced by the sector, efforts should be undertaken to tap into this knowledge base and scale up actions, to meet the goals set out by countries in their NDCs. The elaboration of NAPs provide a timely opportunity for countries to set up the framework for adaptation actions in the sector. Such efforts can be complemented by prioritization efforts at the sub-national level, which can help develop targeted actions. However, no single innovation by itself will offer a solution, and a portfolio of innovations is needed, supported by a conducive, enabling environment which encourages innovative business models to scale up, and creates the right incentives for the flow of finance. As demonstrated in this paper, carefully designed interventions not only deliver benefits for climate change adaptation but also for environmental sustainability, nutrition and livelihoods, thus offering additional value to investors.

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