RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

# Info Note

# Climate change, food security and small-scale producers

*Analysis of findings of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)*

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**APRIL 2014**

**The findings of AR5 lead us to seven priorities for action:**

- **Urgency**: since climate change is affecting food and farming now, we need to speed up the pace of adaptation, and to achieve mitigation co-benefits wherever possible.
- **Investment:** we need to increase the proportion of climate finance going into adaptation, and to secure a flow of resources to locations and populations where adaptation needs are greatest.
- **Private finance:** we need creative finance and insurance products to improve both risk management and access to capital for adaptation actions, especially among small producers.
- **Value chains:** we need to pay more attention to how food value chains are managed, to deal with climate risks, secure affordable and nutritious food supplies for poor consumers, and improve the links for small producers and processors to stable markets, whether local or distant.
- **Knowledge:** since climate change is not static, we will continually need to generate and share new knowledge, extending the information revolution into fields, forests and fisheries in remote localities.
- **Breeding:** we need to invest now in farmer-led and science-led breeding, as it is demonstrably one of the most effective adaptation measure to the 2030s, and requires 8-20 year lead times for release of new varieties of crops and livestock.
- **Nutrition:** we need to focus development interventions on ensuring not just maintained calorie supply under climate change, but also enabling access to diverse food baskets.

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

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

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

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

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

**How have our knowledge and scientific methods advanced since AR4 in 2007?**

AR5 provides a far more thorough evaluation than AR4 of the impacts of climate change on agriculture and food security. Key advances in scientific methods over the seven years between the two reports include:

- A more holistic understanding of food systems, not just agricultural productivity, with integrated drivers, activities and outcomes for food security.
- Better analysis of uncertainty in impact modeling, e.g. use of ensembles of climate models and systematic comparisons among crop models.
- Greater use of historical empirical evidence on the relationship between climate and food production.
- More experiments on the effects of elevated carbon dioxide that are done in the field rather than in greenhouses

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

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

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

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

*In many parts of Africa, maize will suffer as temperatures rise, but drought-tolerant varieties are already making a difference. Photo: S. Mann (ILRI)*

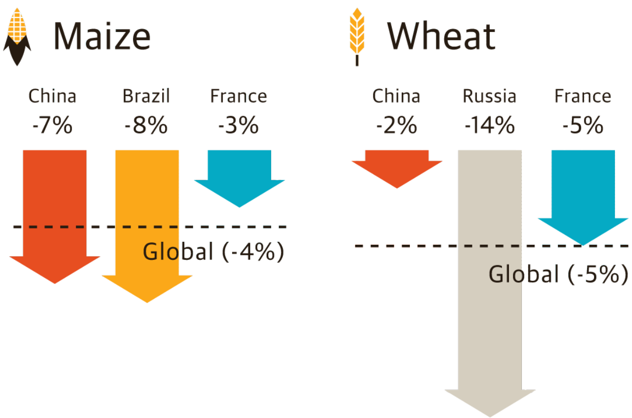
***Climate change has impacts on the nutritional quality and safety of food.*** Cereals grown in elevated carbon dioxide show a decrease in protein and micronutrients, but ozone has the opposite effect. Thus, it is clear that climate trends directly affect nutrition, but there is not yet any confidence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

# Climate change, food and farming: 2010s

According to the Fifth Assessment Report of the IPCC, climate change is affecting food and farming now

## It is affecting crop yields

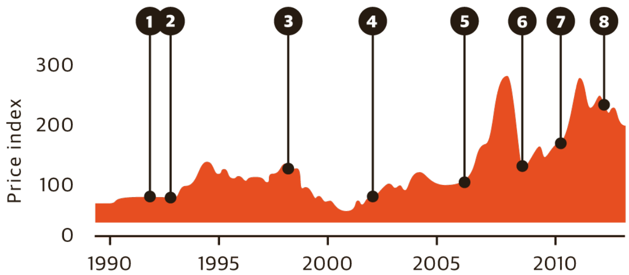
Maize and wheat yields show climate impacts




## It is putting up prices

Recent price spikes for food have been linked to extreme weather events

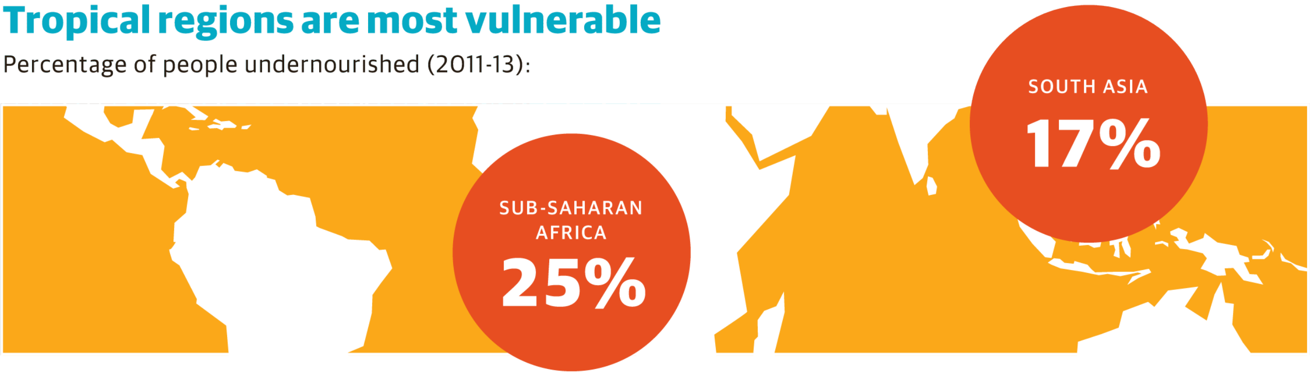
SEASONAL CLIMATE EXTREMES AND THE FOOD PRICE INDEX




**1.** Australia wheat. **2.** US maize. **3.** Russia wheat. **4.** US wheat, India soy, Australia wheat. **5.** Australia wheat. **6.** Argentina maize, soy. **7.** Russia wheat. **8.** US maize.

## Tropical regions are most vulnerable

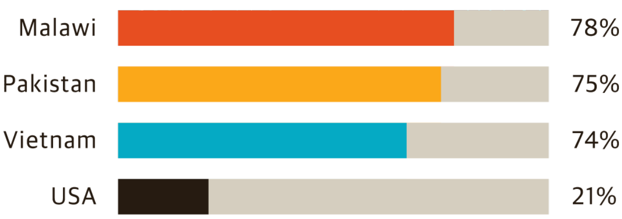
Percentage of people undernourished (2011-13):




## Poor people are worst affected

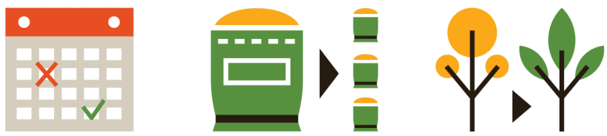
Poor people spend a higher proportion of their income on food – so price rises affect them more

HOW MUCH OF THEIR INCOME DO POOR PEOPLE SPEND ON FOOD?




## Adaptation is happening, but is not enough

Farmers are:



Changing planting dates

Adjusting marketing arrangements

Using different crop cultivars and species

SOURCES: Porter, J. R., Xie, L., Challinor, A., Cochrane, K., Howden, M., Iqbal, M. M., Lobell, D., Travasso, M. I. 2014. Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc-wg2.gov/
With data from Lobell et al 2011, FAO 2014, US DOL 2014

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

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

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

## 2030s: Options for adaptation as climate change advances

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

*Irrigation of food crops during the dry season in drought-affected Nicaragua is possible thanks to special reservoirs to capture and store excess rainwater during the country's rainy season. Photo: N. Palmer (CIAT).*

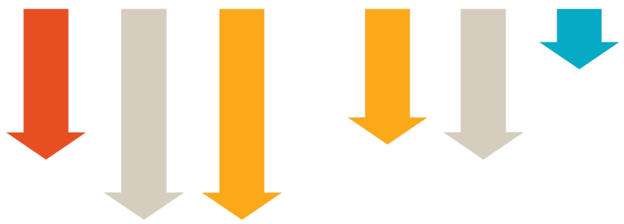
***Climate risks will continue to multiply threats to poor producers in rural areas.*** Rural areas will continue to be home to the majority of poor people for at least the next few decades, even as population growth is higher in urban areas. Livelihoods in rural areas will continue to be in large part dependent on agriculture, while climate risks to agriculture are expected to increase. Greater exposure to climate risk, without insurance, leads small-scale producers to: (1) prefer low-risk, low-return subsistence crops over high-risk, high-return cash crops (2) be less likely to apply fertilizer or other purchased inputs and (3) defer adoption of new technologies. Together these responses will increasingly reduce both current and future farm profits, and thus increase food insecurity among already poor rural populations.

# The future of food and farming: 2030s

In the 2030s, climate change will affect food and farming more strongly, particularly small-scale producers in poor countries

## Crop and pasture yields are likely to decline in many places

| North-East Brazil | | | Central America | | | East Africa | | New Zealand |
|---|---|---|---|---|---|---|---|---|
| Maize | Rice | Wheat | Wheat | Rice | Bean | Maize | Bean | Pasture for beef and dairy |
| -10% | -14% | -14% | -9% | -10% | -4% | -3% | -1.5% | -4% |

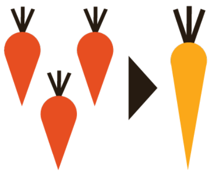


Small-scale producers with fewer assets will need most support to adapt – such as disaster relief, farm insurance and weather forecasts

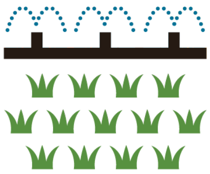
## Adaptation will be key

### CROPS

Temperate regions will benefit more from adaption than tropical regions



Switching to varieties tolerant to heat, drought or salinity

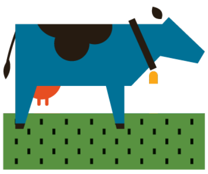


Optimising irrigation

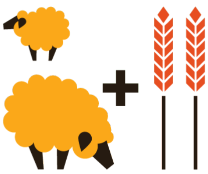
Managing soil nutrients and erosion

### LIVESTOCK

Key adaptations for small-scale producers include:



Matching animal numbers to changes in pastures

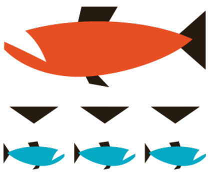


More farms that mix crops and livestock

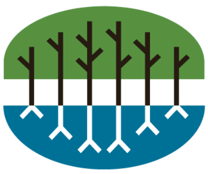
Controlling the spread of pests, weeds and diseases

### FISHERIES

Key adaptations for small-scale fisheries include:



Switching to more abundant species



Restoring degraded habitats and breeding sites like mangroves

Strengthening infrastructure such as ports and landing sites

SOURCES: Porter, J. R., Xie, L., Challinor, A., Cochrane, K., Howden, M., Iqbal, M. M., Lobell, D., Travasso, M. I. 2014. Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc-wg2.gov/
With data from ECLAC 2009, Lobell et al 2008, Margulis, et al 2010, Thornton, et al 2010, Wratt et al 2008

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

*A farmer inspects his millet crop in Ghana's Upper West Region, which has suffered failed rains and rising temperatures. Photo: N. Palmer (CIAT).*

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

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

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

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

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

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

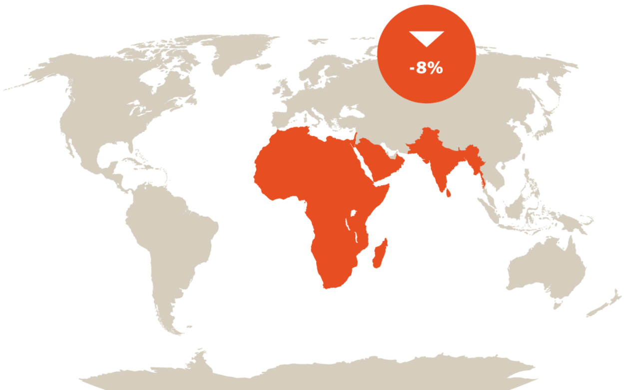
By the 2050s, global population will have risen to around 9 billion people and societies will have undergone further shifts in urbanization, aging, diets and wealth distribution. AR5 makes it clear that it is from the 2050s onwards that climatic impacts on food security will be unmistakable, particularly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

# The future of food and farming: 2050s

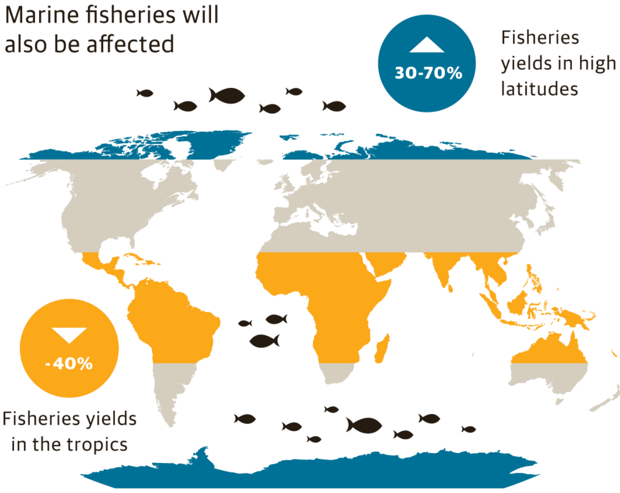
By 2050, climatic impacts on food security will be unmistakable. There are likely to be 9 billion people on the planet, most people will live in cities and demand for food will increase significantly.

## Widespread impacts on food and farming are highly likely

Average decline in yields for eight major crops across Africa and South Asia

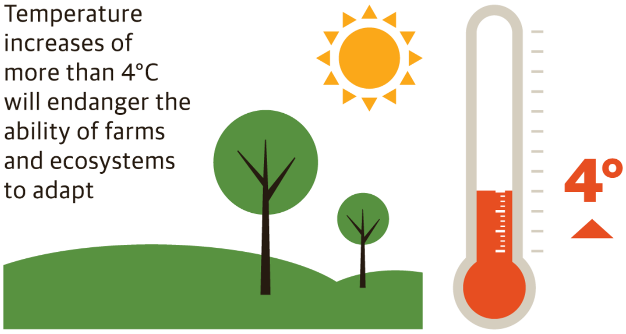



Marine fisheries will also be affected




## Heat and water may pass critical thresholds

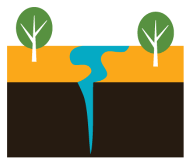
Temperature increases of more than 4°C will endanger the ability of farms and ecosystems to adapt




Water cycles will be very different and less predictable

Changes in the intensity, frequency and seasonality of precipitation

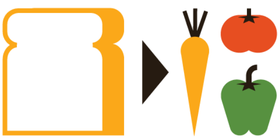
Sea level rises and melting glaciers



Changes in groundwater and river flows

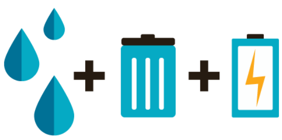
## We will need major innovations in how we eat and farm

To cope with climatic changes, we may need to consider:



Completely different diets

Shifting production areas for familiar crops, livestock and fisheries



New approaches to managing waste, water and energy in food supply chains

Restoring degraded farmlands, wetlands and forests

SOURCES: Porter, J. R., Xie, L., Challinor, A., Cochrane, K., Howden, M., Iqbal, M. M., Lobell, D., Travasso, M. I. 2014. Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc-wg2.gov/
With data from Cheung et al 2010, Cochrane et al 2009, Knox et al 2012

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

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

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

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

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

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

**Key knowledge gaps on climate change and food security**

- **Post-farming stages of food chains**: Need more studies on climate change risks in food supply chains, with development of cost-effective adaptation options.
- **Systemic and transformational adaptation**: Most research in adaptation in agriculture focuses on near-term on-farm agronomic changes. Less is known about options for large-scale change e.g. in global production areas of key foods.
- **Extreme climate events**: Difficult to model but have important impacts on food availability and prices at multiple scales. Specific types of extremes, such as floods, remain under-researched.
- **Ozone**: The interactive effects of ozone with other environmental factors such as carbon dioxide, temperature, moisture and light, are important but not well understood.
- **Livestock production**: Overall much less evidence to date than for crop systems; known to depend particularly on climatic impacts on pasture or cultivated feed.
- **Aquaculture**: Need for greater knowledge on how aquaculture is impacted as climate change, and its value as an adaptation option for future protein supplies.
- **Wild foods**: Almost no climate change research to date, aside from capture fisheries.
- **Pests and diseases**: Changed geographical ranges are expected, but changes in disease intensity remain unclear, whether for crop, livestock or fisheries diseases. Climate change impacts on soil organisms, including pathogens, are little understood.

***Climate change will affect food security by its impacts on all sectors, not just agriculture.*** Small-scale food producers may benefit or suffer from food price rises, depending on the balance between their sales of produce and their purchases of food. For a small number of countries like Indonesia where (a) a large proportion of poor people are in agriculture and (b) the yield impacts of climate change are projected to be lower than elsewhere, climate change may result in a decrease in poverty and increase in food security among farmers, as a result of rising food prices. For most countries, however, food price rises and declining productivity would outweigh the benefits of higher prices to farmers. More generally, food security is largely an outcome of the balance between incomes and food prices for the majority of consumers who depend on paid labour and marketed food. The negative effects of climate change on productivity of most economic sectors is likely to reduce incomes and hence food security.

***System-wide and transformative adaptation will become increasingly necessary in agriculture and food systems.*** Most research and policy discussion around adaptation in agriculture focuses on incremental changes, mostly on-farm and within existing systems of farming and food production. With increasing climate change, there may well be a need for larger-scale systemic and transformative changes, such as major shifts in diets, food supply chain management, and localities of agricultural production. AR5 argues that there may be opportunity costs in focusing on incremental adaptation at the expense of systemic or transformative change, for example in systems of land allocation, breeding of varieties that are functionally different from what we produce now, and incentives for using land and water for different purposes, such as ecosystem services. The time is ripe now for policy-makers to engage farmers and others in decisions and action to transform agriculture.

## Further Reading


- Field CB, Barros VR, Mastrandrea MD, et al. 2014. Summary for Policy Makers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc-wg2.gov
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