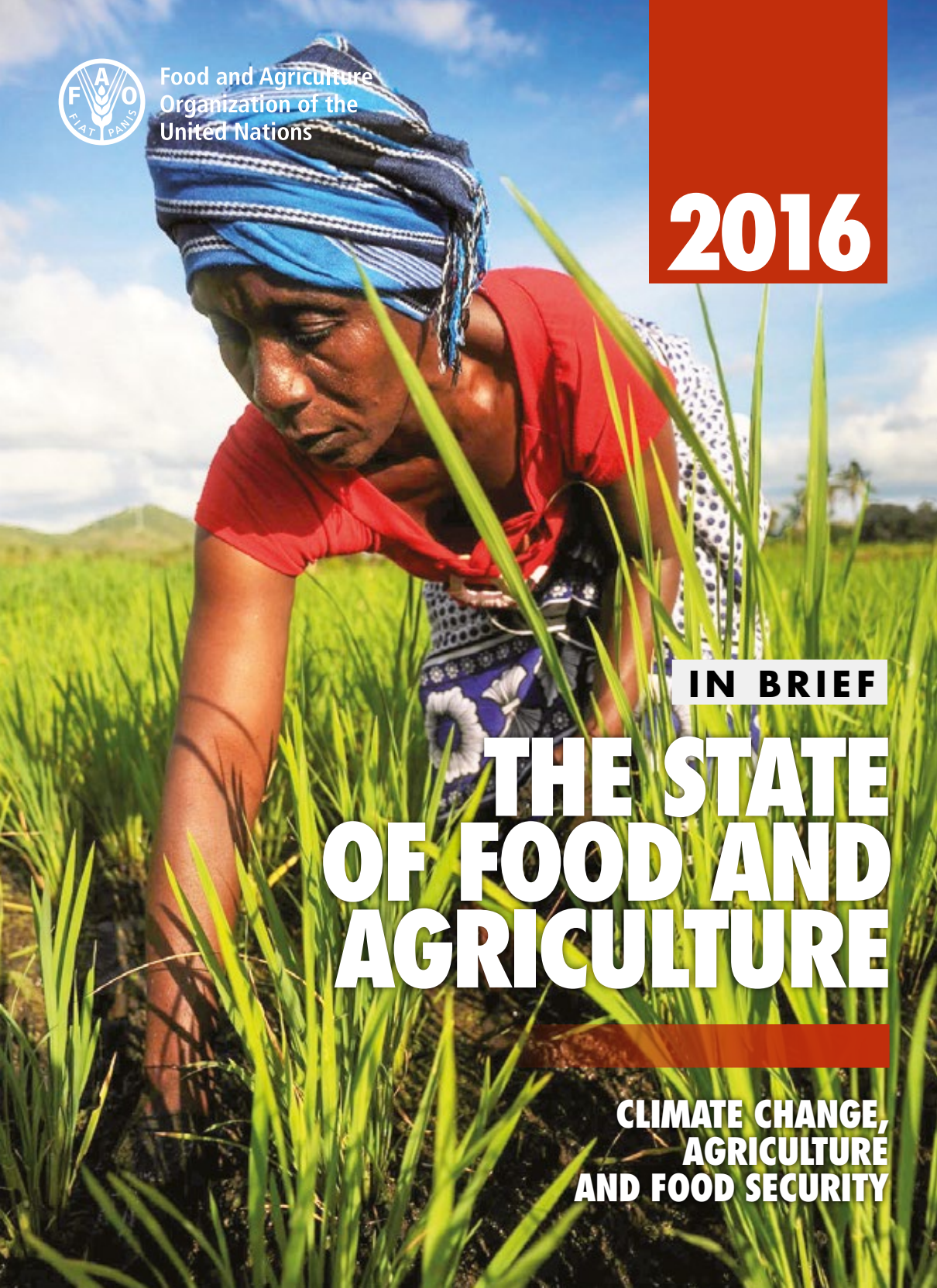


Food and Agriculture Organization of the United Nations

2016

IN BRIEF

THE STATE OF FOOD AND AGRICULTURE

CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY

CONTENTS

The numbering of and notes to the tables and figures correspond to the main publication.

COVER PHOTOGRAPH

KIROKA, UNITED REPUBLIC OF TANZANIA. Hand weeding a rice paddy forms part of the System of Rice Intensification method in this climate-smart agriculture project. ©FAO/D. Hayduk

SIEM REAP, CAMBODIA
Participatory Natural resource Management in the Tonle Sap Region: GCP/CMB/008/BEL.
©FAO/J. Thompson

FOREWORD

Following last year's historic Paris Agreement and the 2030 Agenda for Sustainable Development – marking a path towards a more sustainable future – 2016 is about putting commitments into action. The rapid change in the world's climate is translating into more extreme and frequent weather events, heat waves, droughts and sea-level rise.

The impacts of climate change on agriculture and the implications for food security are already alarming – they are the subjects of this report. A major finding is that there is an urgent need to support smallholders in adapting to climate change. Farmers, pastoralists, fisherfolk and community foresters depend on activities that are intimately and inextricably linked to climate – and these groups are also the most vulnerable to climate change. They will require far greater access to technologies, markets, information and credit for investment to adjust their production systems and practices to climate change.

Unless action is taken now to make agriculture more sustainable, productive and resilient, climate change impacts will seriously compromise food production in countries and regions that are already highly food-insecure. These impacts will jeopardize progress towards the key Sustainable Development Goals of ending hunger and poverty by 2030; beyond 2030, their increasingly negative impacts on agriculture will be widespread.

Through its impacts on agriculture, livelihoods and infrastructure, climate change threatens all dimensions of food security. It will expose both urban and rural poor to higher and more volatile food prices. It will also affect food availability by reducing the productivity of crops, livestock and fisheries, and hinder access to food by disrupting the livelihoods of millions of rural people who depend on agriculture for their incomes.

Hunger, poverty and climate change need to be tackled together. This is, not least, a moral imperative as those who are now suffering most have contributed least to the changing climate. The report describes ways of adapting smallholder

production to climate change and making the livelihoods of rural populations more resilient. Diversification and better integration of food production systems into complex ecological processes create synergies with the natural habitat instead of depleting natural resources. Agroecology and sustainable intensification are examples of approaches that improve yields and build resilience through practices such as green manuring, nitrogen-fixing cover crops and sustainable soil management, and integration with agroforestry and animal production.

More resilient agriculture sectors and intelligent investments into smallholder farmers can deliver transformative change, and enhance the prospects and incomes of the world's poorest while buffering them against the impacts of climate change. This report shows how the benefits of adaptation outweigh the costs of inaction by very wide margins. For this transformation towards sustainable and more equitable agriculture, access to adequate extension advice and markets must improve, while insecurity of tenure, high transaction costs, and lower resource endowments, especially among rural women, are barriers that will need to be overcome.

Livelihood diversification can also help rural households manage climate risks by combining on-farm activities with seasonal work, in agriculture and in other sectors. In all cases, social protection programmes will need to play an important role – in helping smallholders better manage risk, reducing vulnerability to food price volatility, and enhancing the employment prospects of rural people who leave the land.

In order to keep the increase in global temperature below the crucial ceiling of 2 °C, emissions will have to be reduced by as much as 70 percent by 2050. Keeping climate change within manageable levels can only be achieved with the contribution of the agriculture sectors. They now account for at least one-fifth of total emissions, mainly from the conversion of forests to farmland as well as from livestock and crop production. The challenge is to reduce those emissions while meeting unprecedented demand for food.

FOREWORD

The agriculture sectors can substantially contribute to balancing the global carbon cycle. Similarly, in the forestry sector, avoiding deforestation, increasing the area under forest, and adopting sustained-yield management in timber production can bind large amounts of atmospheric carbon dioxide (CO_2). Soils are pivotal in regulating emissions of CO_2 and other greenhouse gases. Appropriate land use and soil management lead to improved soil quality and fertility and can help mitigate the rise of atmospheric CO_2.

It is essential that national commitments – the country pledges that form the basis of the 2015 Paris Agreement on climate change – turn into action. The Conference of the Parties that will be held in November 2016 in Morocco will have a clear focus on implementation in the agriculture sectors. This report identifies strategies, financing opportunities and data and information needs, and describes transformative policies and institutions that can overcome barriers to implementation. As countries revise and, hopefully, ramp up their national plans, success in implementing their commitments – particularly in the agriculture sectors – will be vital to creating a virtuous circle of higher ambition.

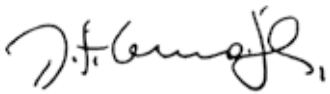
Climate change is a cornerstone of the work undertaken by FAO. To assist its Members, we have invested in areas that promote food security hand in hand with climate change adaptation and mitigation. FAO is helping to reorient food and agricultural systems in countries most exposed to climate risks, with a clear focus on supporting smallholder farmers.

FAO works in all its areas of expertise, pursuing new models of sustainable, inclusive agriculture. Through the Global Soil Partnership, FAO promotes investment to minimize soil degradation and restore productivity in regions where people are most vulnerable, thus stabilizing global stores of soil organic matter.

We participate in the Global Agenda for Sustainable Livestock, and have launched a programme to reduce enteric emissions of methane from ruminants using measures suited to local farming systems. In the fisheries sector, our Blue Growth Initiative is integrating fisheries and sustainable environmental management, while a joint programme with the European Union aims at protecting carbon-rich forests. We provide guidance on including genetic diversity in national climate change adaptation planning, and have joined forces with the United Nations Development Programme to

support countries as they integrate agriculture in adaptation plans and budgeting processes. FAO also helps link developing countries to sources of climate financing.

The international community needs to address climate change today, enabling agriculture, forestry and fisheries to adopt climate-friendly practices. This will determine whether humanity succeeds in eradicating hunger and poverty by 2030 and producing food for all. "Business as usual" is not an option. Agriculture has always been the interface between natural resources and human activity. Today it holds the key to solving the two greatest challenges facing humanity: eradicating poverty, and maintaining the stable climatic corridor in which civilization can thrive.



José Graziano da Silva

FAO Director-General

EXECUTIVE SUMMARY

THE WORLD FACES AN UNPRECEDENTED DOUBLE CHALLENGE: TO ERADICATE HUNGER AND POVERTY AND TO STABILIZE THE GLOBAL CLIMATE BEFORE IT IS TOO LATE

In adopting the goals of the 2030 Agenda on Sustainable Development and the Paris Agreement on Climate Change, the international community took responsibility for building a sustainable future. But meeting the goals of eradicating hunger and poverty by 2030, while addressing the threat of climate change, will require a profound transformation of food and agriculture systems worldwide.

Achieving the transformation to sustainable agriculture is a major challenge. Changes will need to be made in a way that does not jeopardize the capacity of the agriculture sectors – crops, livestock, fisheries and forestry – to meet the world's food needs. Global food demand in 2050 is projected to increase by at least 60 percent above 2006 levels, driven by population and income growth, as well as rapid urbanization. In the coming decades, population increases will be concentrated in regions with the highest prevalence of undernourishment and high vulnerability to the impacts of climate change. At the same time, efforts by the agriculture sectors to contribute to a carbon-neutral world are leading to competing demands on water and land used to produce food and energy, and to forest conservation initiatives that reduce greenhouse gas emissions but limit land available for crop and livestock production.

CLIMATE CHANGE ALREADY AFFECTS AGRICULTURE AND FOOD SECURITY **and, without urgent action, will put millions of people at risk of hunger and poverty.**

The transformation will also need to involve millions of food producers in adapting to climate change impacts, which are already being felt in the agricultural sectors and especially so in tropical regions, which are home to most of the poor and food insecure. It must also reverse the widespread degradation of agriculture's natural resource base – from soil to forests to fisheries – which threatens the very sustainability of food production.

DEEP TRANSFORMATIONS IN AGRICULTURE AND FOOD SYSTEMS, **from pre-production to consumption, are needed in order to maximize the co-benefits of climate change adaptation and mitigation efforts.**

A broad-based transformation of food and agriculture systems is needed, therefore, to ensure global food security, provide economic and social opportunities for all, protect the ecosystem services on which agriculture depends, and build resilience to climate change. Without adaptation to climate change, it will not be possible to achieve food security for all and eradicate hunger, malnutrition and poverty.

BECAUSE ADVERSE IMPACTS WILL WORSEN WITH TIME, A GLOBAL TRANSFORMATION TO SUSTAINABLE FOOD AND AGRICULTURE MUST BEGIN NOW

The effects of climate change on agricultural production and livelihoods are expected to intensify over time, and to vary across coun-

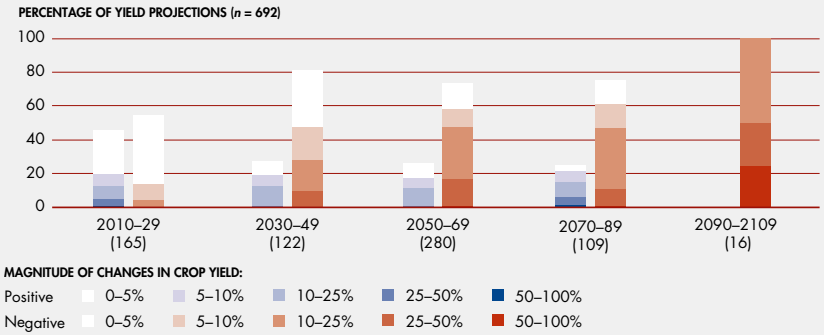
tries and regions. Beyond 2030, the negative impacts of climate change on the productivity of crops, livestock, fisheries and forestry will become increasingly severe in all regions.

Productivity declines would have serious implications for food security. Food supply shortfalls would lead to major increases in food prices, while increased climate variability would accentuate price volatility. Since the areas most affected would be those with already high rates of hunger and poverty, food price increases would directly affect millions of low-income people. Among the most vulnerable will be those who depend on agriculture for their livelihood and income, particularly smallholder producers in developing countries.

While climate change is but one driver of poverty and food insecurity, its impacts are expected to be substantial. In the absence of climate change, and with continuing economic progress, most regions are projected to see a decline in the number of people at risk of hunger by 2050. With climate change, however, the population living in poverty could increase by ▶

FIGURE 5

PROJECTED CHANGES IN CROP YIELDS IN DEVELOPING REGIONS OWING TO CLIMATE CHANGE

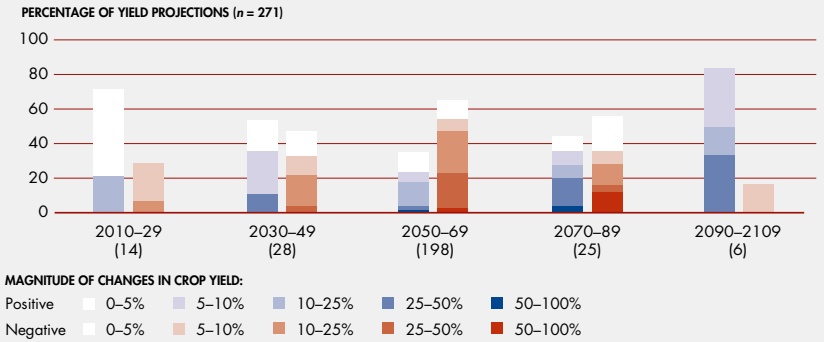


Notes: Number of estimates of change in crop yield is shown in parentheses. Developing regions include all observations from locations in **developing regions of Africa, Latin America, Oceania and all of Asia other than Central Asia**. See Annex table A1 for details.

SOURCES:
See Figure 4.

FIGURE 6

PROJECTED CHANGES IN CROP YIELDS IN DEVELOPED REGIONS OWING TO CLIMATE CHANGE



Notes: Number of estimates of change in crop yield is shown in parentheses. Developed regions include all observations from locations in **developed regions such as Europe, Northern America and Australasia**. See Annex table A1 for details.

SOURCES:
See Figure 4.

TABLE 2

SELECTED POTENTIAL IMPACTS OF CLIMATE CHANGE, BY REGION

	NORTH AMERICA	LATIN AMERICA AND THE CARIBBEAN	EUROPE
CROPS AND LIVESTOCK	▸ Yields of major crops decline modestly by mid-century but more steeply by 2100 ▸ Climate favours fruit production in the Great Lakes region, while late season heat stress challenges US soybean yields ▸ Reduced precipitation restricts water availability as irrigation demand increases ▸ Heat stress and lower forage quality reduce milk production and weight gain in cattle	▸ In temperate areas, soybean, wheat and pasture productivity increases ▸ Drier soils and heat stress reduce productivity in tropical and subtropical regions ▸ Increased salinization and desertification in arid zones of Chile and Brazil ▸ Rainfed agriculture in semi-arid zones faces higher crop losses	▸ Temperate and polar regions benefit from changes ▸ Initial benefits in mid-latitude countries turn negative with higher temperatures ▸ Climate-induced variability in wheat production increases in Southern and Central Europe ▸ High temperatures and humidity increase livestock mortality risk
FISHERIES AND AQUACULTURE	▸ Many warm- and cool-water species move to higher latitudes ▸ Arctic freshwaters experience the greatest warming and most negative impacts ▸ Warmer waters and lower water quality increase disease risks to North Atlantic cetaceans and tropical coral reefs	▸ Primary production in the tropical Pacific declines and some species move southwards ▸ More frequent storms, hurricanes and cyclones harm Caribbean aquaculture and fishing ▸ Changes in freshwater fish species physiology, collapse of coral reef systems	▸ Warming displaces some fish populations northwards or to deeper waters ▸ Invasive tropical species alter coastal ecosystems in southern Europe's semi-enclosed seas ▸ Aquaculture impacted by sea-level rise, acidification, temperature increases
FORESTRY	▸ Pine forest pest damage increases with higher spring temperatures ▸ Warmer summers boost forest fire risk by up to 30 percent ▸ Warmer winters favour bark beetles responsible for forest die-off	▸ Tropical forests are affected more by changes in the water availability and CO_2 fertilization than by temperature changes ▸ In Amazonia, increased risk of frequent fires, forest loss and "savannization" ▸ In Central America, 40 percent of mangrove species are threatened with extinction	▸ In Northern and Atlantic Europe, higher temperatures and atmospheric CO_2 levels increase forest growth and wood production ▸ Shrubs increasingly replace trees in Southern Europe ▸ An increase in wildfires leads to a significant increase in greenhouse gas emissions

SOURCE: Compiled from IPCC (2007, 2014) and FAO (2011, 2016c).

- Overall impacts on yields of cereals, especially maize, are negative across the region
- The frequency of extremely dry and wet years increases
- Much of southern Africa is drier, but rainfall increases in East and West Africa
- Rangeland degradation and drought in the Sahel reduce forage productivity

- Rising temperatures threaten wheat production in North Africa and maize yields region-wide
- There is a general decline in water availability, but a slight increase in Sudan, Somalia and southern Egypt
- In mid-latitudes, higher temperatures lead to richer pastures and increased livestock production
- Warmer winters benefit livestock, but summer heat stress has negative impacts

- Agricultural zones shift northwards as freshwater availability declines in South, East and Southeast Asia
- Higher temperatures during critical growth stages cause a decline in rice yields over a large portion of the continent
- Demand for irrigation water increases substantially in arid and semi-arid areas
- Heat stress limits the expansion of livestock numbers

- In New Zealand, wheat yields rise slightly but animal production declines by the 2030s
- In Australia, soil degradation, water scarcity and weeds reduce pasture productivity
- In the Pacific islands, farmers face longer droughts but also heavier rains
- Higher temperatures increase the water needs of sugarcane

- Sea-level rise threatens coastlands, especially in West Africa
- By 2050, declining fisheries production in West Africa reduces employment in the sector by 50 percent
- East African fisheries and aquaculture are hit by warming, oxygen deficit, acidification, pathogens
- Changes along coasts and deltas (e.g. death of coral reefs) impact productivity

- Usable water resources in many Mediterranean and Near East basins decline further
- Warming boosts productivity in the Arabian Sea
- Catch potential falls by as much as 50 percent in some parts of the Mediterranean and Red Seas

- Coastal flooding seriously affects capture fisheries and aquaculture in large river deltas
- A general decline in coastal fisheries production and greater risk of extreme events in the aquatic systems
- Redistribution of marine capture fisheries, with numbers declining in the tropics
- Freshwater aquaculture faces major risks of freshwater scarcity
- By 2050, the body weight of marine fish falls by up to 24 percent

- Changes in water temperature and currents increase the range of some pelagic species, reduce that of others
- Changes in water temperature and chemistry strongly affect fisheries and aquaculture
- Nutrient decline reduces krill populations along Australia's east coast
- Small island states, highly exposed and highly reliant on fisheries, suffer most

- Deforestation, degradation and forest fires affect forests in general
- Forest losses reduce wildlife, bush meat and other non-wood forest production
- Water scarcity affects forest growth more than higher temperatures

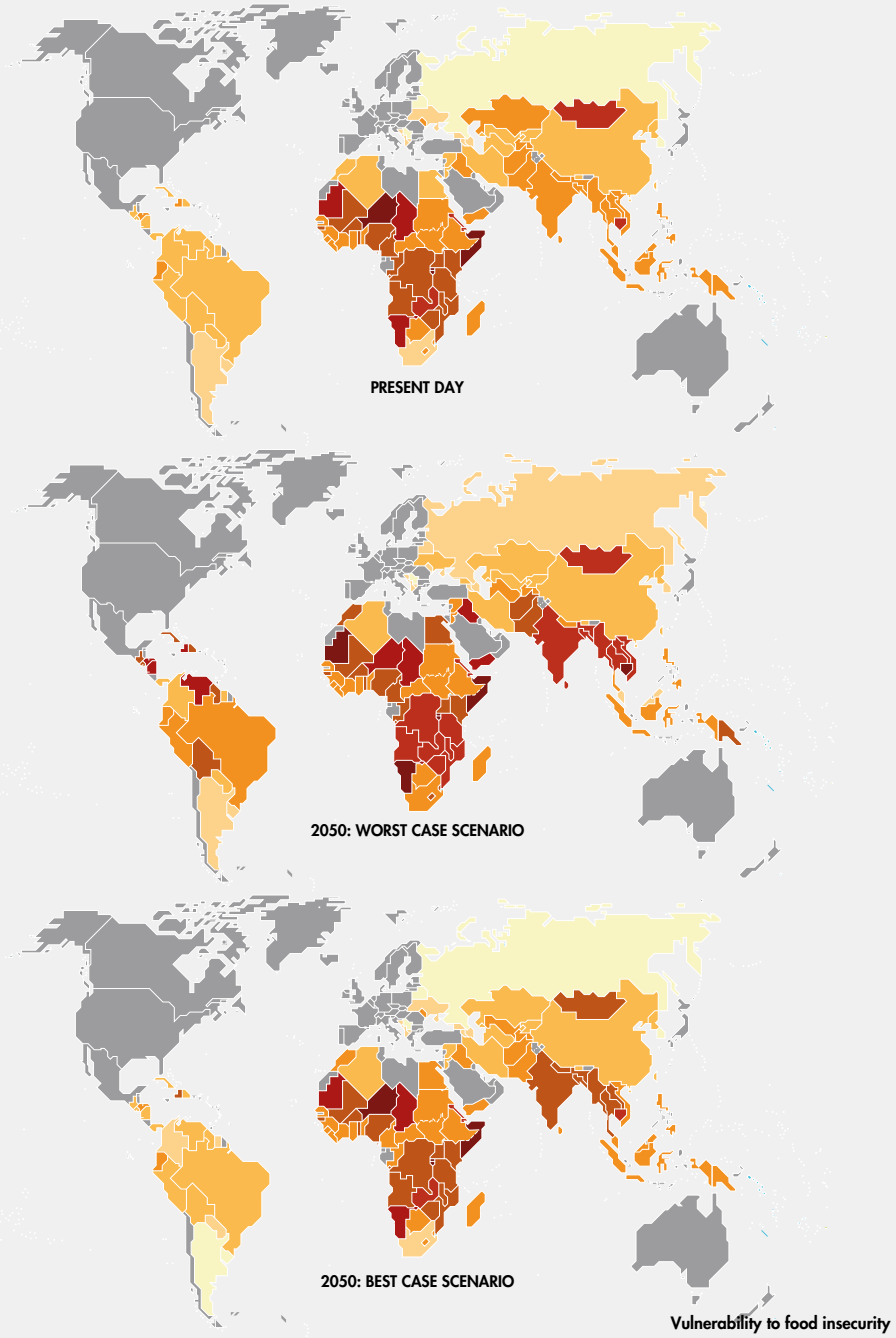
- Soil moisture depletion reduces the productivity of major forest species, increases fire risk, and changes pest and disease patterns
- In the Near East, declining summer rains lead to severe water shortages that affect forest growth

- Boreal forests and Tibetan plateau alpine vegetation shift northwards
- Many forest species face extinction owing to combined effects of climate change and habitat fragmentation
- A general increase in the frequency and extent of forest fires and the risk of invasive species, pests and diseases

- Productivity increases owing to CO_2 fertilization are counterbalanced by the effects of rising temperatures and reduced rainfall
- In the Pacific, extreme weather events damage mangrove forests

FIGURE 10

FOOD INSECURITY AND CLIMATE CHANGE VULNERABILITY: PRESENT DAY, WORST CASE AND BEST CASE SCENARIOS



SOURCE: Met Office Hadley Centre and WFP, 2015.

TABLE 3

NUMBER OF PEOPLE LIVING IN EXTREME POVERTY IN 2030 WITH AND WITHOUT CLIMATE CHANGE, UNDER DIFFERENT CLIMATE AND SOCIO-ECONOMIC SCENARIOS

		Climate change scenario				
		No climate change	Low-impact		High-impact	
		Number of people in extreme poverty	Additional number of people in extreme poverty due to climate change			
Socio–economic Scenario	Prosperity	142 million	+3 million		+16 million	
			Minimum	Maximum	Minimum	Maximum
			+3 million	+6 million	+16 million	+25 million
	Poverty	900 million	+35 million		+122 million	
			Minimum	Maximum	Minimum	Maximum
			–25 million	+97 million	+33 million	+165 million

Notes: The main results use the two representative scenarios for prosperity and poverty. The ranges are based on the 60 alternative scenarios for each category. See Box 7 for an explanation of RCPs and SSPs.
SOURCE: Adapted from Rozenberg and Hallegatte (2015).

- between 35 and 122 million by 2030 relative to a future without climate change, largely due to its negative impacts on incomes in the agricultural sector. The increase in the number of poor would be biggest in sub-Saharan Africa, partly because its population is more reliant on agriculture.

Food and agriculture must be central to global efforts to adapt to climate change, through policies and actions that address vulnerabilities and risks and promote agricultural systems that are resilient and sustainable. This action must begin now – with the increasing intensity of climate change impacts, building resilience will become ever more difficult. Delaying the transformation of the agricultural sectors will force poorer countries to fight poverty, hunger and climate change at the same time.

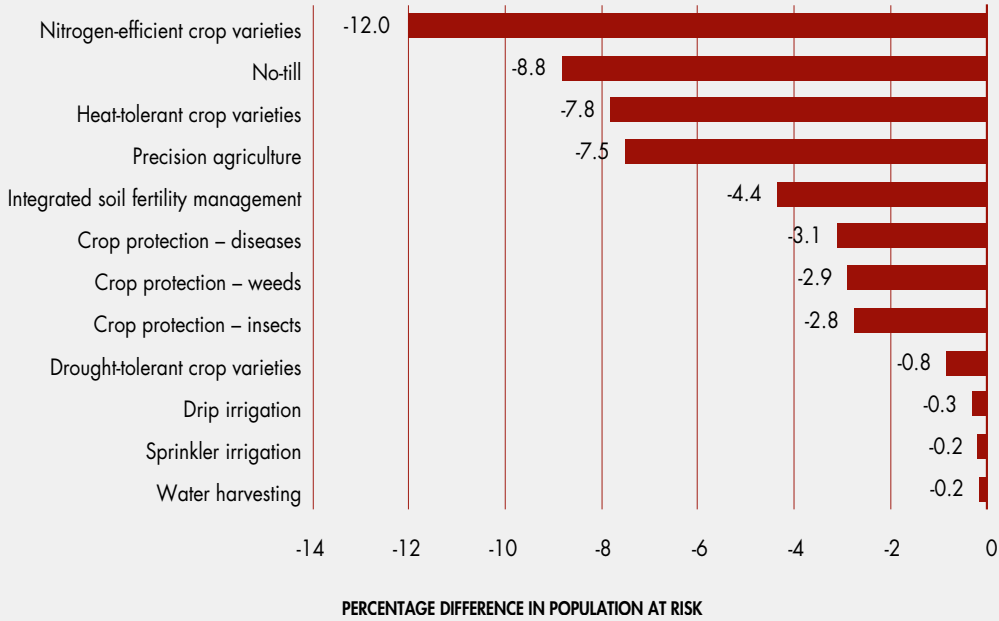
ECONOMICALLY VIABLE AND SUSTAINABLE FARMING PRACTICES ARE AVAILABLE, BUT BARRIERS TO THEIR ADOPTION MUST BE OVERCOME

Significant improvements in food security, as well as resilience to climate change can be achieved with the introduction of sustainable agricultural practices. Wide adoption of practices such as the use of nitrogen-efficient and heat-tolerant crop varieties, zero-tillage and integrated soil fertility management would boost productivity and farmers' incomes, and help lower food prices. By one estimate, the number of people at risk of undernourishment in developing countries in 2050 could be reduced by more than 120 million through widespread use of nitrogen-efficient crop varieties alone.

Despite this potential, the adoption by farmers of improved practices is still very limited. Often, adoption is hampered by policies, such as input subsidies, that perpetuate unsustainable production practices rather than those that promote resource-use efficiency, soil conservation and the reduction in the intensity of agriculture's own greenhouse gas emissions. Smallholders, especially, face a broad range of barriers on the path to sustainable agriculture, such as limited access to markets, credit, extension advice, weather information, risk management tools and social protection. Women, who make up around 43 percent of the agricultural labour force in developing

FIGURE 14

CHANGE IN 2050 IN THE NUMBER OF PEOPLE AT RISK OF HUNGER, RELATIVE TO THE BASELINE SCENARIO, AFTER ADOPTION OF IMPROVED AGRICULTURAL TECHNOLOGIES



SOURCE: Rosegrant *et al.* (2014), based on simulations with IFPRI's IMPACT model.

countries, are especially disadvantaged, with fewer endowments and entitlements than men, even more limited access to information and services, gender-determined household responsibilities, and increasingly heavy agricultural workloads owing to male out-migration.

There is no simple "technological fix". What is needed is a reorientation of agricultural and rural development policies that resets incentives and lowers the barriers to the transformation of food and agricultural systems. Particular attention should be given to supporting low-income smallholder farmers in strengthening their capacity to manage risks and adopt effective climate change adaptation strategies.

MOVING BEYOND FARMING PRACTICES: SMALLHOLDERS' ADAPTATION TO CLIMATE CHANGE RISKS WILL BE CRITICAL FOR GLOBAL POVERTY REDUCTION AND FOOD SECURITY

The sheer number of smallholder farm families in developing countries – some 475 million – justifies a specific focus on the threat posed by climate change to their livelihoods and the urgent need to transform those livelihoods along sustainable pathways. It will be difficult, if not im-

GLOBAL POVERTY CANNOT BE ERADICATED WITHOUT STRENGTHENING **the resilience of smallholder agriculture to climate change impacts.**

possible, to eradicate global poverty and end hunger without building resilience to climate change in smallholder agriculture through the widespread adoption of sustainable land, water, fisheries and forestry management practices. With other enabling factors in place – such as adequate access to credit and markets, but also action to eliminate legal, socio-cultural and mobility constraints on rural women – those practices have been found to yield significant productivity improvements. However, improved management practices may not be enough to sustain farmer incomes.

IMPROVEMENTS IN INFRASTRUCTURE, EXTENSION, CLIMATE INFORMATION, MARKET ACCESS, CREDIT AND SOCIAL INSURANCE are needed to facilitate adaptation and diversification of smallholder livelihoods.

Farmers can further enhance their resilience through diversification, which can reduce the impact of climate shocks on income and provide households with a broader range of options when managing future risks. One form of diversification is to integrate production of crops, livestock and trees – for example, some agroforestry systems use the leaves of nitrogen-fixing leguminous trees to feed cattle, use manure to fertilize the soil, and grow pulses to provide extra protein during periods of seasonal food insecurity.

For farm households with limited options for on-farm diversification, livelihood diversification through non-farm rural employment or migration to cities may be essential. Adaptation through sustainable intensification and agricultural diversification may have to be combined, therefore, with the creation of off-farm opportunities, both locally and through strengthened rural-urban linkages. Gender issues may need to be addressed – social norms often prevent women from pursuing off-farm activities. Social protection, education and active labour market policies are needed to mitigate many of the risks associated with diversification and migration.

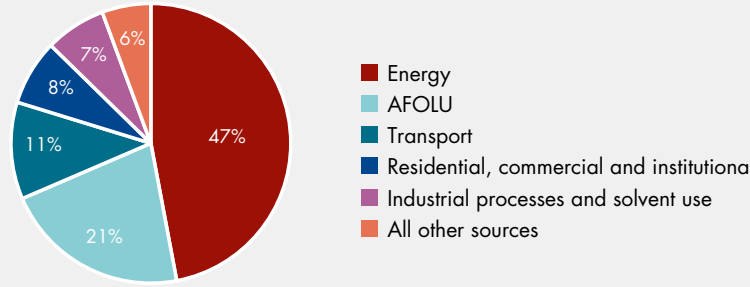
ONE-FIFTH OF GREENHOUSE GAS EMISSIONS ARE GENERATED BY AGRICULTURE, FORESTRY AND LAND-USE CHANGE; THE AGRICULTURE SECTORS NEED TO CONTRIBUTE TO CONTAINING GHG EMISSIONS

The challenge of adaptation to climate change will become greater over time if we do not act now to reduce emissions of the greenhouse gases responsible for global warming. Emissions will have to be drastically reduced in order to keep climate change in check and keep the global temperature increase no higher than 1.5 °C or 2 °C, compared with pre-industrial levels. This is a global responsibility and requires all economic sectors to shift to low emission intensity.

Agriculture, and the food sector at large, have an important responsibility in climate change mitigation. Taken together, agriculture, forestry and land-use change account for about one-fifth of global GHG emissions. Carbon dioxide emissions from agriculture are mainly attributable to losses of above and below ground organic matter, through changes in land use, such as conversion of forests to pasture or cropland, and land degradation such as caused by over-grazing. The bulk of direct

FIGURE 2

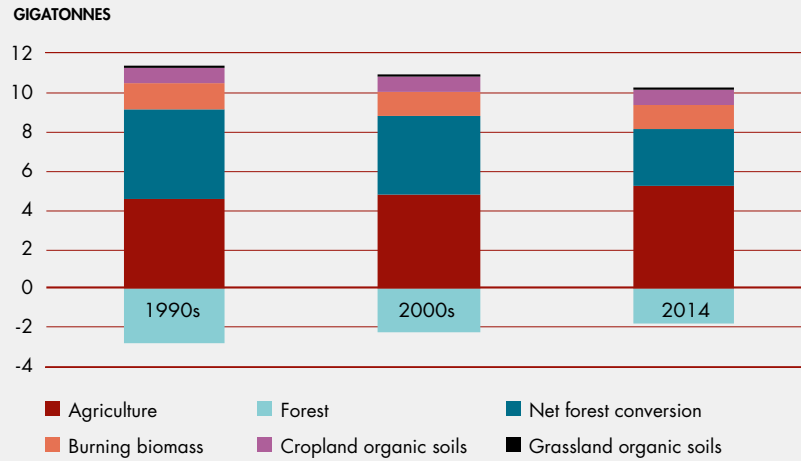
SHARES OF GREENHOUSE GAS EMISSIONS FROM ECONOMIC SECTORS IN 2010



Notes: Emissions from energy include industries, manufacturing and fugitive emissions. AFOLU means "Agriculture, forestry and other land use". "All other sources" includes international bunkers, waste and other sources.
SOURCE: FAO, forthcoming.

FIGURE 11

ANNUAL AVERAGE NET EMISSIONS/REMOVALS FROM AFOLU IN CO_2 EQUIVALENT



Note: See Notes on the Annex tables for definitions.
SOURCE: FAO, 2016d. See Annex table A.2 for details.

emissions of methane and nitrous oxide, two potent GHGs, are the result of enteric fermentation in livestock, rice production in flooded fields, and the application of nitrogen fertilizer and manure, all of which can be reduced through the implementation of better management practices.

The share of the food system as a whole in total global GHG emissions is even greater – further emissions are generated by the manufacture of agrochemicals, by fossil energy use in farm operations, and in post-production transportation, processing and retailing.

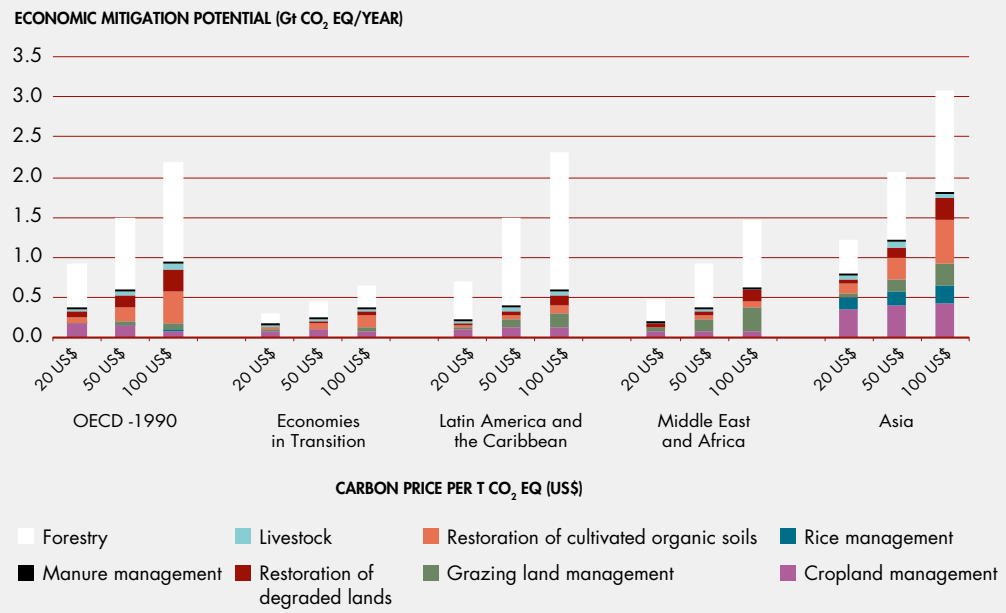
AGRICULTURE'S CONTRIBUTION TO CLIMATE CHANGE ADAPTATION AND MITIGATION IS FEASIBLE – BUT REQUIRES ACTION ON A BROAD FRONT

Broad-based agricultural and rural development can help reduce exposure and sensitivity to climate shocks and enable farmers to benefit from new opportunities for improving rural livelihoods and food security. This report shows how the adoption of improved management practices will help to achieve a significant reduction in the number of food insecure. However, improvements in infrastructure, extension, climate information, access to credit, and social insurance, which are at the heart of rural development, need to go hand in hand in order to foster the adoption of improved practices and the diversification of rural livelihoods.

Available estimates suggest that the aggregate cost of adaptation and making farm systems more resilient are only a fraction of the costs of inaction. Adaptation efforts make good economic sense and also have considerable potential to reduce the GHG emissions generated by agriculture, forestry and land-use change. Increasing resource-use efficiency, cutting the use of fossil fuels and avoiding direct environmental degradation will save farmers money, enhance productivity sustainably and reduce dependence on external inputs.

FIGURE 15

ECONOMIC MITIGATION POTENTIAL IN THE AFOLU SECTOR IN 2030, BY REGION



SOURCE: Smith *et al.*, 2014, Figure 11.17.

Multiple concrete examples exist of how efforts at adaptation and mitigation can go hand in hand. Improvements in crop production and fertilizer management appear to offer the greatest potential for reducing nitrous oxide emissions, while also reducing input costs. Increasing stocks of soil organic carbon improves crop yields and builds resilience to drought and flooding, but also sequesters carbon. Alternate wetting and drying of rice fields reduces methane emissions from paddies by 45 percent, while saving water and producing yields similar to those of fully flooded rice. In both temperate and tropical regions, farming system diversification and crop-livestock-tree integration could increase farm-scale efficiency, reduce emissions intensity and raise productivity. In the livestock sector, the general adoption of sustainable practices could cut livestock methane emissions by up to 41 percent while also increasing productivity through better animal feeding, animal health and herd structure management. However, the uptake of these practices is often low in many areas. Efforts to foster their adoption by smallholders need to be informed by a thorough understanding of the existing financial, institutional and policy barriers.

THE AGRICULTURE SECTORS FACE A UNIQUE CHALLENGE:
to produce more food while reducing greenhouse gas emissions caused by food production.

As agricultural production increases to meet demand, so too will its emissions. Major improvements in the management of the carbon and nitrogen cycles in agriculture would be needed to achieve a reduction in emission intensities – or emissions per unit of agricultural output – to counterbalance the tendency of the agriculture sectors to emit more as they produce more. Hence, achieving the mitigation potential in the agriculture sectors will not be easy – not only because of the major transformations needed in agriculture for broader adoption of improved practices, but also because of projected increases in demand for agricultural products.

Not all mitigation options can be seen as adaptation measures with important mitigation co-benefits. Other initiatives are intrinsically driven by a mitigation motive. For example, putting a halt to deforestation and forest degradation arguably has the largest potential for emission reduction in the agriculture sectors. This should be a top priority, but will require accepting trade-offs: reducing deforestation often comes at a cost to the farmer. Efforts in this direction are under way through the REDD+ initiative, under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC). Although emissions from the conversion of forests have declined significantly over the past two decades, the trade-offs involved make these gains fragile. Unlike other economic sectors where adaptation and mitigation actions are generally independent of each other, in the agriculture sectors the objectives of food security, adaptation and mitigation, are interlinked.

Even the widespread adoption of climate-smart, sustainable agriculture may fall short of what is needed to meet global climate targets. Big adjustments are required

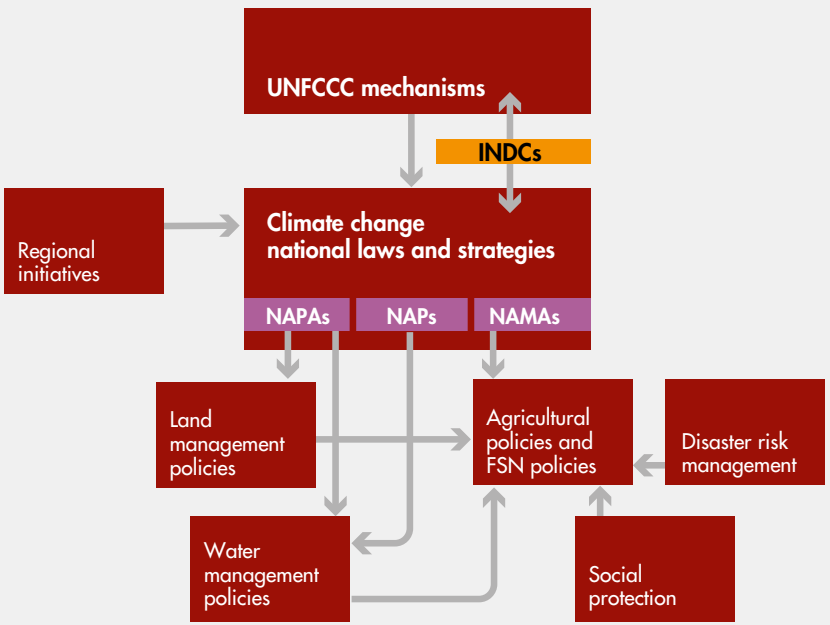
in food systems at large. About one-third of all food produced in the world is lost or wasted post-harvest. Reducing food losses and waste would not only improve the efficiency of the food system, but would also reduce both pressure on natural resources and emissions of greenhouse gases. The energy use and emission-intensity of food processing, conservation and transportation are high and increasing. Reducing emission intensity along the entire food chain will require significant changes in consumer awareness, as well as price incentives that favour food items with much smaller environmental footprints. Rebalancing diets towards less animal-sourced foods would make an important contribution in this direction, with probable co-benefits for human health.

PARIS AGREEMENT COMMITMENTS NEED TO UNDERPIN SYSTEM-WIDE ACTION IN FOOD AND AGRICULTURE

Transformative change in agriculture and food systems appears to be economically and technically feasible. However, change will only come about if supported by appropriate policies, institutional frameworks and investment finance mechanisms. These enabling factors are important for agricultural development in general, but are made even more necessary by climate change. Policy frameworks need to be drastically modified to align agricultural development, food security and nutrition, and climate stability objectives.

FIGURE 16

FROM INTERNATIONAL COMMITMENTS AND MECHANISMS TO NATIONAL POLICIES AND INSTITUTIONS



SOURCE: FAO.

The Intended Nationally Determined Contributions (INDCs), which formed the basis of the 2015 Paris Agreement on Climate Change, are now to become Nationally Determined Contributions (NDCs) to global climate objectives, through policies and actions. The agriculture sectors feature prominently in the INDCs, with 94 percent of all countries including them in their mitigation and/or adaptation contributions. Developing countries highlight the importance of agriculture and food security for adaptation; often, they also include the agriculture sectors as contributing to their mitigation targets. Around one-third of all countries refer in their INDCs to the potential co-benefits between mitigation and adaptation in agriculture. There is a clear willingness of countries to respond to climate change by transforming and investing in the agriculture sectors.

Many countries have designed broad climate change policies and strategies, which establish global objectives and targets. However, few have spelled out the details of action plans to achieve climate targets. The INDCs are a first step in a much broader process of rethinking agricultural and rural development under climate change. The UNFCCC has already established meaningful mechanisms, such as National Adaptation Plans, to underpin concerted actions to address climate change. In line with the policy recommendations of this report, those mechanisms should be integrated into broader agricultural and food security and nutrition policies, and vice-versa.

POLICIES ON CLIMATE, AGRICULTURE, FOOD AND NUTRITION SHOULD BE REALIGNED AND INTEGRATED

Policies, market forces and environmental constraints drive the use of inputs and other resources in agriculture, influencing productivity and the degree of conservation or depletion of natural resources. Policy-making for agriculture under climate change should start from an understanding of those drivers and their impacts on farmers' livelihoods and the environment. This is a complex task and win-win solutions may not always be possible. Drivers vary significantly between countries and regions – smallholder farmers do not have the same capacity as global agribusinesses to respond to policy and market signals.

Policymakers must recognize the need to manage trade-offs, and set out concrete measures for better aligning multiple objectives and incentive structures. For example, the gender equity trade-offs of planned actions need to be systematically analysed – a shift to more resilient intercropping systems has sometimes cost women their control over specific crops. One area with a large potential for policy realignment is the redesign of agricultural support measures in a way that facilitates, rather than impedes, the transition to sustainable agriculture. In 2015, developed and major developing countries spent more than US$560 billion on agricultural production support, including subsidies on inputs and direct payments to farmers. Some measures, such as input subsidies, may induce inefficient use of agrochemicals and increase the emissions

intensity of production. Making support conditional upon the adoption of practices that lower emissions and conserve natural resources is one way of aligning agricultural development and climate goals.

Policies on nutrition, food consumption, food price support, natural resources management, infrastructure development, energy and so on, may similarly need to be re-set. To address trade-offs, the process must ensure greater inclusiveness and transparency in decision-making, as well as incentives that provide long-term public and collective benefits. For example, experience shows that forests can be well managed and degradation reversed by involving local communities, supported by legitimate decentralized institutional arrangements developed through consultative processes.

Climate change brings new risks. Managing them requires enhanced forms of collective action and systems that assess risks, vulnerabilities and adaptation options. Well-designed social protection programmes, which guarantee minimum incomes or access to food, have an important role to play, but should be aligned with other forms of climate risk management. Instead of simply responding to extreme events, disaster risk reduction should be embedded in broader strategies for climate change adaptation.

In responding to climate change, international cooperation and multi-stakeholder partnerships and alliances are essential. For example, climate change will lead to new pests and disease problems and increase the risks of their transboundary movement. Strengthened regional and international cooperation will be needed to facilitate information and knowledge sharing, to manage common resources such as fish stocks, and to conserve and utilize agrobiodiversity. Cooperation is also needed to close gaps in our knowledge of climate change impacts on agriculture, food security and nutrition, to evaluate the scalability and economic viability of sustainable farming practices, and to assess the ecological footprint of food systems at large.

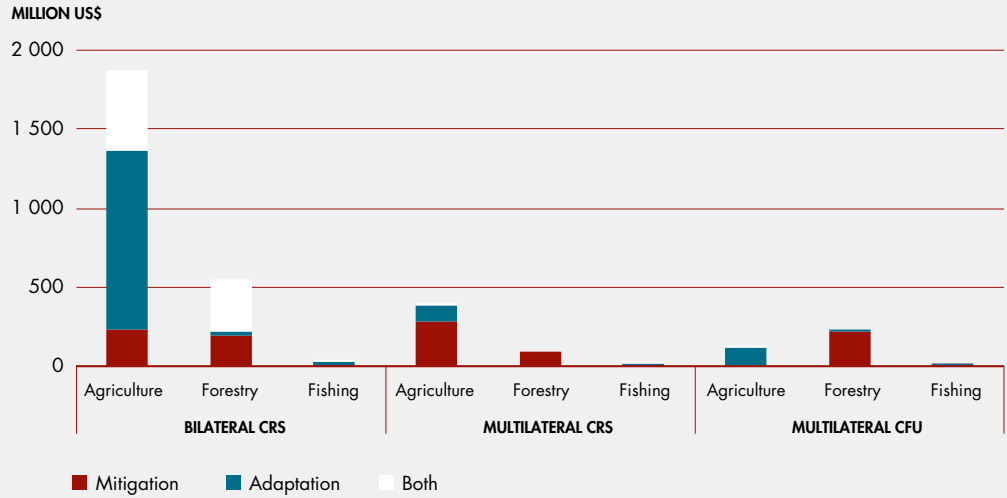
AGRICULTURAL AND CLIMATE FINANCE NEED TO BE LINKED AND LEVERAGED TO INDUCE TRANSFORMATIVE CHANGE IN AGRICULTURE

More climate financing and agricultural investments are need to facilitate the transition to sustainable agricultural practices. However, available finance for investment in agriculture falls well short of needs. Smallholder producers in developing countries face major hurdles in accessing credit for investing in new technologies and practices, and female farmers even more so. The shortfall in finance limits investment in agriculture and food security and, with it, the capacity of smallholders to adapt to climate change.

More climate finance needs to flow to agriculture to fund the investment cost associated with the required large-scale transformation of its sectors and the development of climate-smart food production systems. Additional finance from public sources, as well as customized financial products, will be needed in two areas of financing.

FIGURE 17

AVERAGE ANNUAL INTERNATIONAL PUBLIC FINANCE FOR MITIGATION AND/OR ADAPTATION BY SECTOR AND SOURCE, 2010-14



Notes: "CRS" is OECD's Creditor Reporting System; "CFU" is ODI's Climate Fund Update. To avoid double counting, some adjustments were made. See Annex to Chapter 6 for details.
SOURCES: Bilateral and multilateral CRS estimates are from OECD (2015a) and multilateral CFU are from ODI (2015).

First, more upfront support is necessary for increasing farmers' productivity, building capacity to adapt to climate change and reducing the emissions intensity of production. This will require a significant increase in the amount of finance available, and more flexible conditions, such as repayment schedules adjusted to cash flows. This approach would allow farmers to make the investments that maintain current yields using fewer resources, and apply climate-smart practices and technologies that increase resilience while reducing emissions. However, for this to be successful, a second area requires financing – building capacity through appropriate institutions and policies, so that farmers are enabled to undertake transformational changes. Improving the enabling environment is especially needed for the vast majority of smallholder farmers, who are effectively disenfranchised from climate financing and denied opportunities for investing in productive activities that would improve their livelihoods, productivity and incomes.

MORE CLIMATE FINANCE IS NEEDED to fund developing countries' planned actions on climate change in agriculture.

Although more climate finance is needed for the transformation envisioned by this report, additional funding will also require improving countries' capacity to make things happen on the ground. Systemic capacity constraints currently hamper developing country access to and effective use of climate finance for agriculture. This "capac-

ity gap" in policy-making and institutional development, which can manifest itself at both funding and receiving ends, hinders support for the transition to sustainable agriculture. Closing these capacity gaps should be made a priority by funders and countries alike, so that climate finance – if countries ramp up funding as planned – can serve its transformative role for food and agriculture.

Climate finance can also act as a catalyst to leverage larger flows of public and private funding for sustainable agriculture, provided policies and institutional frameworks that promote transformative change are in place. Climate finance could help address the funding gap by demonstrating the viability of climate-smart agricultural investments, and designing and piloting innovative mechanisms to leverage additional sources of investment. Climate funds – if used strategically to build the enabling environment essential for climate-smart agricultural development, to ensure that public agricultural investment is climate-smart, and to leverage private finance – could become an important catalyst for climate change adaptation and mitigation.

By filling the financing gap and catalysing investment, climate finance can strengthen risk management mechanisms, foster development of appropriate financial products, and address the capacity constraints of lenders and borrowers. It is crucial, therefore, to strengthen the enabling environment for climate-smart agricultural investments, mainstream climate change considerations in domestic budget allocations and implementation, and unlock private capital for climate-smart agricultural development. Until that happens, the climate financing needed for investment in smallholder agriculture will continue to be inadequate, with serious consequences in terms of loss of livelihoods and increased food insecurity.

The time to invest in agriculture and rural development is now. The challenge is garnering diverse financing sources, aligning their objectives to the extent possible, and creating the right policy and institutional environments to bring about the transformational change needed to eradicate poverty, adapt to climate change and contribute to limiting greenhouse gas emissions. ■

2016
THE STATE OF FOOD AND AGRICULTURE

CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY

Unless action is taken now to make agriculture more sustainable, productive and resilient, climate change impacts will seriously compromise food production in countries and regions that are already highly food-insecure. The Paris Agreement, adopted in December 2015, represents a new beginning in the global effort to stabilize the climate before it is too late. It recognizes the importance of food security in the international response to climate change, as reflected by many countries focusing prominently on the agriculture sector in their planned contributions to adaptation and mitigation.

To help put those plans into action, this report identifies strategies, financing opportunities, and data and information needs. It also describes transformative policies and institutions that can overcome barriers to implementation.

2016 The State of Food and Agriculture (full text)

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