A1 Introducing Climate-Smart Agriculture

Overview

To feed an expanding population, the annual world food production will need to increase by 60 percent over the next three decades (Bruinsma, 2009). However, the impacts of climate change, which include increasing temperatures, shifting precipitation patterns, more severe and frequent extreme weather events and the loss of ecosystem services and biodiversity, ¬will undermine agricultural production systems and food systems, especially in agricultural communities in developing countries where poverty, hunger and malnutrition are the most prevalent (Africa progress Panel, 2010; Zezza *et al*., 2008; Porter *et al*., 2014). The agricultural sectors, which include crop and livestock production, forestry, fisheries and aquaculture, are also a major contributor to global greenhouse gas emissions. According to FAO estimates, in 2010, emissions from the agriculture, forestry and other land use (AFOLU) sector directly accounted for 22 percent of total global emission (FAO, 2016a).

The agriculture sectors need to overcome three intertwined challenges: sustainably increase agricultural productivity to meet global demand; adapt to the impacts of climate change; and contribute to reducing the accumulation of greenhouse gases in the atmosphere. (FAO, 2010; Foresight, 2011; Beddington *et al.*, 2012a; Beddington *et al*., 2012b; HLPE, 2012a). To meet these challenges, FAO has developed and promoted the concept of climate-smart agriculture. Climate-smart agriculture has three objectives: sustainably increase agricultural productivity and the incomes of agricultural producers; strengthen the capacities of agricultural communities to adapt to the impacts of climate change; and, where possible, reduce and/or remove greenhouse gas emissions.

To reach these objectives, agriculture production systems and food systems will need to use natural resources and other inputs more efficiently and become more resilient to change. Transformations will need to be made in the field, at all stages of the food value chain and in policy-making processes at the local, national and international levels. Everyone has a stake in this process – agricultural producers; the businesses that are involved in processing, distributing and marketing agricultural goods; the consumers who depend on these goods; national, subnational and local governments, intergovernmental organizations, non-governmental organizations, civil society organizations and research institutions. It will take long-term coordinated effort by all stakeholders to make the transition to climate-smart agriculture.

Since FAO introduced the concept of climate-smart agriculture at the 2010 Hague Conference on Agriculture, Food Security and Climate Change, there has been growing support at international and national levels for this approach. More than 30 countries, most of them from in sub-Saharan Africa, specifically refer to climate-smart agriculture in the Intended Nationally Determined Contributions (INDCs) they submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Many other countries have emphasized the importance of the agriculture sectors in their INDCs. The INDCs, which serve as the foundation of the Paris Agreement on climate change, outline the national roadmaps for addressing climate change. The 2015 Paris Agreement represents a major step in the global effort to combat climate change.

The first section of this module gives an overview of climate-smart agriculture, as an approach to address in a comprehensive way the interlinked challenges of achieving sustainability, increasing food security and responding to climate change. The second section describes an overall framework for building resilience and increasing efficiency in various agricultural production systems. The third section briefly touches upon some of the issues to be addressed to implement climate-smart agriculture and make progress towards efficient and resilient agriculture production systems and food systems. The last section articulates how the concept of climate-smart agriculture is embedded in the broader development agenda, as outlined in the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) and other international initiatives to promote sustainable food and agriculture. It also touches upon the links between climate-smart agriculture and other approaches to sustainable agricultural development.

Key messages

- Agricultural production systems and food systems must undergo significant transformations to meet the interlinked challenges of achieving sustainability, increasing food security and responding to climate change.
- Increasing efficiency in the use of natural resources and other agricultural inputs is a central element for making agriculture climate-smart.
- Building resilience to the risks associated with climate change is essential for preparing agricultural communities to cope with the uncertainty created by changing climatic conditions.
- Initiatives to increase efficiency and build resilience have to be considered together at a range of different scales and take into account the environmental, economic and social dimensions of sustainability.
- Climate-smart agriculture is not a new agricultural system, nor a set of practices. It is an innovative approach for charting development pathways that can make the agriculture sectors more productive and sustainable and better able to contribute to climate change adaptation and mitigation.
- Scaling up climate-smart agriculture to achieve the needed transformations in agricultural production systems and food systems requires sound policies, robust institutions and secure financing at the local, national and international levels to create a supportive enabling environment for change.
- Climate-smart agriculture contributes to the implementation of the 2030 Agenda for Sustainable Development and the SDGs, and follows the principles of sustainable food and agriculture.

Sustainability, food security and climate change: three intertwined challenges

Agricultural production systems are facing increasing competition from other sectors for limited natural resources. The availability of these resources and their quality are also being affected by unsustainable management practices and changing climatic and weather conditions. To respond to this situation, the agriculture sectors must improve their sustainability performance and adapt to the impacts of climate change in ways that do not compromise global efforts to ensure food security for all. These challenges are intimately and inextricably related, and need to be addressed simultaneously.

A1–1.1 Ensuring sustainablity in food and agriculture

The concept of sustainability has three dimensions: economic, environmental and social. A sustainable farming system should be a profitable business that creates mutually beneficial relationships among workers and the surrounding community, and contributes to the sound management of the land and other natural resources. SDG 2, 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture', makes it clear how important the promotion of sustainable agriculture is to the 2030 Agenda for Sustainable Development. As their name suggests, the SDGs have a strong focus on all the dimensions of sustainability.

The heightened emphasis on sustainability in agriculture is due to the fact that the recent achievements in agriculture, which have led to major improvements in productivity that have enabled food production to keep up with population growth, have often come at high social and environmental costs. For example, FAO (2011a) estimates that, as a result of the combined demands of agriculture and other sectors, more than 40 percent of the world’s rural population lives in river basins that are classified as water scarce. Each year, soil erosion destroys 10 million hectares of cropland. Forty percent of this loss is due to tillage erosion (Pimentel, 2006). Genetic erosion, which is partly a result of intensive agricultural production systems that use fewer and more genetically uniform crop varieties, has created a situation where genetic vulnerability (when a widely planted crop is uniformly susceptible to a pest, pathogen or environmental hazard as a result of its genetic constitution) threatens agricultural production in 60 countries. Progress in raising agricultural production has been made largely by producers that have access to inputs and markets, and secure rights to use the land and other resources, which many smallholder producers, especially women, do not have. As a result social inequity has increased in many rural areas, and food security in agricultural communities in developing countries has remained stubbornly high. All of these collateral effects of modern agricultural production are now jeopardizing the accomplishments of past development strategies, and have pushed sustainability to the very heart of the 2030 Agenda for Sustainable Development (FAO, 2016b).

Sustainable agricultural development is designed to enhance productivity, maintain or restore the soil fertility, increase the efficiency in the management of water and energy resources, conserve and harness genetic resources for food and agriculture, strengthen the rural livelihoods, and promote equity and social well-being. The key to achieving these multiple objectives is the adoption of a systems approach. This involves an examination of the food system as a whole and promoting integrated and harmonized development strategies across the different agricultural sectors and along all the stages of the food value chain in ways that take into account the synergies and the trade-off among the different dimensions of sustainability (FAO 2016b). A greater emphasis on system and integrated approaches is expected to reduce the conflicts over resources, optimize the allocation and use of natural and financial resources and increase the efficiency of the agricultural production systems and the food supply chain.

Sustainable agriculture development can also contribute to increasing economic equity. Introducing sustainable technologies and practices in the agriculture sectors is relatively inexpensive compared to other sectors. In many developing countries, with large numbers of resource-poor producers, it is the only viable development alternative. Sustainable agricultural development is expected to deliver more benefits to impoverished smallholder farmers and increase the resilience of communities that are highly vulnerable to extreme weather events associated with climate change.

Sustainable agriculture development is a process that requires the participation of a large share of the rural population. This participation must be facilitated by supportive policies, institutions and financing, that taken together can create an enabling environment for climate-smart agriculture at local, national and international levels. Making the transition to sustainable agriculture production systems and food value chains requires a collective effort that involves all stakeholders in both the design and the implementation of policies, programmes and investments.

A1–1.2 Ensuring food security

Despite concerted efforts to combat food insecurity, the number of chronically undernourished people in the world is estimated to have increased from 777 million in 2015 to 815 million in 2016 (FAO, IFAD, UNICEF, WFP and WHO, 2017). Nevertheless, over the last fifteen years, progress has been made; in 2000, the number of undernourished people stood at 900 million. However, progress remains unevenly distributed across different regions.

Climate change will have negative impacts on all dimensions of food security (FAO, 2016a). The impacts of climate change on agriculture will be the key channel through which climate change will affect food security. Other impacts of climate change, such as the increased frequency of severe weather events in urban areas will also contribute to food insecurity.

When considering the impacts of climate change on food security and designing strategies to address these impacts, it is critical to understand the different dimensions of food security. FAO has defined four dimensions of food security:

- food availability,
- economic and physical access to food,
- food utilization, and
- stability over time (vulnerability and shocks).

Climate change directly affects food availability through its increasingly adverse impacts on crop and animal productivity and health, and fish stocks, especially in sub-Saharan Africa and South Asia, where most of world's food insecure live. For impoverished agricultural producers, a secure supply of food is not only a basic need, it is the single, and often fragile, means they have for earning an income and maintaining their livelihood. Producers who suffer lower yields will see their ability to access food decline, as they have less money available to purchase food. In addition, declines in the food supply associated with climate change, will likely be reflected in higher food prices. This would affect both the urban and rural poor, as they spend much higher shares of their income on food. Also affected will be poor smallholder family farmers, most of whom are net buyers of food (World Bank, 2008). Climate change can also have impacts on the way food is utilized. Some studies indicate possible impacts in terms of food quality, nutrition and food safety (e.g. Myers *et al*., 2014). Increased climate variability affects the stability of food supplies and food prices through their impact on production. Climate-related shocks can affect those who are not poor but are nevertheless vulnerable and can drag them into poverty, if, for example, a flood destroys a microenterprise, a drought decimates a livestock herd, or contaminated water makes a child sick. These events can erase decades of hard work and the accumulation of assets, and cause irreversible damage to people's health.

Climate change will be just one of several factors that will drive future trends in poverty and food insecurity. Poverty and food insecurity, and the severity of climate change impacts on them, will be determined by overall socio-economic development. A recent World Bank study has estimated poverty levels in 2030 under different climate change and policy scenarios. The study found that under a high climate change impact scenario, the number of people in extreme poverty increases significantly in 2030 by 122 million people; in a scenario of prosperity the increase would be just 16 million. However, the future impacts of climate change on poverty will also be determined by policy choices and targeted adaptation strategies (Hallegatte and Rozenberg, 2016).

A1-1.3 Impacts of climate change on agriculture

Climate change will affect the agricultural sectors in many ways, and these impacts will vary from region to region. For example, climate change is expected to increase temperature and precipitation variability, reduce the predictability of seasonal weather patterns and increase the frequency and intensity of severe weather events, such as floods, cyclones and hurricanes. Some regions are expected to face prolonged drought and water shortages. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2014) also points out that changes in climate and carbon dioxide concentrations will enhance the distribution and increase the competitiveness of important invasive weeds. As a result of climate change, some cultivated areas may become unsuitable for crop production, and some tropical grasslands may become more arid. In sub-Saharan Africa alone, projections predict a loss of 10-20 million hectares of land available for double cropping systems and 5-10 million hectares for triple cropping systems as a result of climate change (Fischer *et al*., 2005; Schmidhuber and Tubiello, 2007). Those changes will have direct effects on agricultural production, which, in turn, will have economic and social consequences that will be reflected in the prevalence of food insecurity. The impacts range from yield reductions, increased yield variability, displacement of crops and livestock breeds, and the loss of agricultural biodiversity and ecosystem services. A large body of evidence points to a prevalence of negative outcomes, with many agricultural systems becoming less productive and some plant and animal species disappearing (e.g. Tirado *et al*., 2010; Porter *et al*., 2014 and HLPE 2012a). Among the most affected areas are economically vulnerable countries that are already food insecure, and food-exporting countries. Consequently, climate change is expected to increase the gap between developed and developing countries, which will be further exacerbated by the relatively lower technical and economical capacities of developing countries to respond to new threats (Padgham, 2009).

In terms of impacts, it is necessary to differentiate between increased variability and slow onset changes. The potential impacts of increased variability are often less emphasized than slow onset changes for a variety of reasons. This is because these impacts are less well known even though they will be felt first (HLPE, 2012a). The impacts of increased variability are situated between the much emphasized category of 'extreme events', and the much more 'easier to grasp' business-as-usual category of actual variability. It is important to distinguish between these two categories of impacts to highlight two ways to adapt, each with different time ranges: increasing resilience now to be prepared for more variability, and increasing adaptive capacities and preparedness for slow onset changes. Furthermore, being prepared for increased variability is also a way to prepare for any other change, whatever it may be.

A1-1.4 Agriculture's impact on climate change

The agricultural sectors are a major contributor to global greenhouse gas emissions. As indicated in the overview this module, FAO estimates that emissions from the AFOLU sector directly accounted for 22 percent of total global emissions in 2010 (FAO, 2016a). These emissions are the result of natural processes and agricultural practices, which makes them more difficult to control and measure. If the emissions caused by energy use within the food value chains are included, the share of greenhouse emission increases to more than 30 percent (FAO, 2011b). As an integral part of the economy, the agricultural sectors have been called upon to contribute to mitigating climate change (UNFCCC, 2008). The critical question is how and to what extent agriculture production systems and food systems can contribute to climate change mitigation without compromising food and nutrition security.

Agricultural production systems and food systems can contribute to mitigating climate change and still keep their focus on a ‘food security first’ objective in a number of other ways. One way is to improve efficiency by decoupling production growth from emissions growth. This involves reducing emissions per kilogram of food output. Also, if the crop and livestock production and forestry sectors are managed sustainably, they can act as 'sinks', capturing and storing carbon in biomass and soil. Their management can play an essential role in managing climate change especially in the long term (Gitz, 2013). The IPCC estimates that nine-tenths of the global mitigation potential of agriculture is linked, not to reduction of agricultural greenhouse gas emissions, but to managing land carbon stocks. This calls for overall improvements in soil fertility, which involves enhancing soil carbon sequestration, reducing tillage, improving grazing and manure management, and restoring organic soils (especially peatlands) and degraded lands. It should be noted that within food value chains, reductions of emissions at some stages could lead to increases elsewhere. For instance, depending on the efficiency of production systems, shorter food chains could reduce emissions form transport but increase emissions from agricultural production. The impact of mitigation interventions at the different stages of the food value chain will depend on the level of development the country has reached. When looking at challenges and opportunities to reduce greenhouse gas emissions in the agriculture sectors, it is paramount to look beyond the production stage, and consider the whole food value chain and the relationship agriculture production systems have with other land uses, especially forestry.

Climate-smart agriculture

A2-2.1 What is climate-smart agriculture and why is it needed?

Climate-smart agriculture is an approach for transforming and reorienting agricultural production systems and food value chains so that they support sustainable development and can ensure food security under climate change. As noted in the overview to this module, climate-smart agriculture has three main objectives: sustainably increase agricultural productivity and incomes; adapt and build resilience to climate change and reduce and/or remove greenhouse gas emissions, where possible. This does not imply that every practice applied in every location should produce 'triple wins' that deliver positive results for each of these three objectives. Rather the climate-smart agriculture approach seeks to reduce trade-offs and promote synergies by taking these objectives into consideration when agricultural producers, policy makers and researchers make decisions at the local, subnational, national and global levels about short- and long-term strategies to address climate change.

Climate-smart agriculture provides the means to help stakeholders at all levels identify agricultural strategies suitable to their local conditions. It is in line with the FAO vision for sustainable food and agriculture and supports the Organization's goal to make crop and livestock systems, forestry, and fisheries and aquaculture more productive and more sustainable.

Box A1.1 Genesis of the climate-smart agriculture concept

The FAO approach to sustainable food and agriculture recognizes that countries will pursue multiple objectives across the economic, social and environmental dimensions of sustainability. Every country will need to balance the trade-offs between different objectives and between short-term and long-term needs. The major components of climate-smart agriculture were developed in response to debates and controversies related to climate change and agricultural policy for sustainable development in the framework of UNFCCC.

Although the concept of climate-smart agriculture is relatively new, it has already evolved since it was introduced at the 2010 Hague Conference on Agriculture, Food Security and Climate Change (FAO, 2010). The concept emerged at a time when, agriculture’s key role in food security was not clearly articulated in the global climate change policy arena, and the splitting of adaptation and mitigation in two separate negotiation streams limited the capacity to build synergies between these two actions. The first articulation of the concept was presented in the 2009 FAO report, *Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies*, which was launched at the Barcelona Climate Change workshop. The initial articulations of the concept argued that the agricultural sectors are key to climate change response, not only because of their high vulnerability to the impacts of climate change, but also because they are a main contributor of greenhouse gases. It also argued that the sustainable transformation of the agricultural sector is key to achieving food security, and thus it is essential to frame climate change responses within this priority (Lipper and Zilberman, 2017).

After the Hague conference, two parallel global processes were established; one related to policy and the other to science, which led to the establishment of the Global Alliance for Climate-Smart Agriculture (GACSA).

Climate-smart agriculture is not a set of practices that can be universally applied, but rather an approach that involves different elements that are embedded in specific contexts and tailored to meet local needs. Climate-smart agriculture builds on sustainable agriculture approaches, using principles of ecosystem and sustainable land and water management and landscape analysis, and assessments of the use of resources and energy in agricultural production systems and food systems. This is particularly important in developing countries, where agricultural growth is generally a top priority. Often, but not always, practices with strong adaptation and food security benefits can also lead to reduced greenhouse gas emissions or increased carbon sequestration. However, implementing these synergistic practices may entail higher costs, particularly for up-front financing. Therefore, programmes promoting the climate-smart agriculture approach need to include capacity development for local stakeholders to help them tap into sources of funding for agricultural and climate-related investment. Innovative financing mechanisms that link and blend climate and agricultural finance from the public and private sector are critical for the implementation of climate-smart agriculture. These innovations will only be realized if climate-smart agriculture is integrated into policy-making processes at all levels, and there is cross-sectoral coordination in policy design and implementation. The scaling up of context-specific climate-smart agriculture practices will require effective institutional and governance mechanisms to facilitate the dissemination of information and ensure broad participation.

A2-2.2 How is climate-smart agriculture implemented?

Climate-smart agriculture relates to actions in fields, pastures, forests, and oceans and freshwater ecosystems. It involves the assessment and application of technologies and practices, the creation of a supportive policy and institutional framework and the formulation of investment strategies. Climate-smart agricultural systems include different elements such as:

- the management of land, crops, livestock, aquaculture and capture fisheries to balance near-term food security and livelihoods needs with priorities for adaptation and mitigation;
- ecosystem and landscape management to conserve ecosystem services that are important for food security, agricultural development, adaptation and mitigation;
- services for farmers and land managers that can enable them to better manage the risks and impacts of climate change and undertake mitigation actions; and
- changes in the wider food system including demand-side measures and value chain interventions that enhance the benefits of climate-smart agriculture.

Designing a national climate-smart agriculture approach requires the coordination of activities of a wide range of stakeholders. This clearly includes the private sector, as it will be individual agricultural producers, both large-scale and small-scale, who will need to adopt climate-smart agriculture practices, as will other enterprises involved in the food value chain. The financial sector and possibly governments will need to be involved in the provision of credit for investment in activities that contribute to climate-smart agriculture objectives. Governments at all levels will need to establish an enabling policy and regulatory environment for the private sector to stimulate the scaling up of climate-smart agriculture. Research institutions and rural agricultural extension services will need to be included in the policy-making process, and generate and disseminate of information on climate variability and its economic and social implications. Climate-smart agriculture activities can range over a very broad spectrum, depending on the relative importance of its three objectives – food security, adaptation, and mitigation – in a given country.

The methodology FAO has developed with its partner countries for implementing the climate-smart-agriculture approach nationally includes five action points:

1. Expand the evidence base

Given the importance of growth in the agricultural sector for food security and the major impacts climate change is already having on agricultural growth strategies, the first step in implementing a climate-smart agriculture approach is to develop a robust evidence base. The purpose of this step is to formulate strategies for increasing productivity and agricultural incomes, and estimate their potential mitigation co-benefits. An important part of building the climate-smart agriculture evidence base involves determining the current and projected effects of climate change on specific agricultural production systems and producers in the near and medium term, and pinpointing key vulnerabilities in the agricultural sectors and for food security. Another major component in developing the evidence base is the identification and evaluation of potential climate-smart options for adapting to the expected impacts of climate change while at the same time supporting sustainable agricultural development. These activities need to use economic and social criteria that are in line with national food security and development objectives. In making the initial assessment, consideration needs to be given to the potential synergies and trade-offs for the proposed climate-smart agriculture interventions relative to the baseline activities. The final piece in the construction of a robust evidence base is determining the institutional and financing needs that must be met to implement the priority actions. This includes estimating the costs and barriers to the adoption of different practices, identifying issues related to the sustainability of production systems and preparing the required policy and institutional responses. Both analytical work and stakeholder consultations are needed to build the evidence base. The process also needs to recognize various points of view and take into account uncertainty, as there are still many unknowns about the impacts climate change will have on agriculture, particularly in local settings.

2. Support enabling policy frameworks

The existence of a robust evidence base is necessary but not sufficient for the implementation of effective climate-smart agriculture and food security policies. Enabling policy frameworks (e.g. national agricultural development plans, provisional and local extensions to national plans) are essential for ensuring this evidence base is put to use to support climate-smart agriculture. The development of supportive policies, plans and investments, and coordination in the policy-making processes and institutions responsible for agriculture, climate change, food security and land use are required to create this enabling policy framework. There may be a need to modify existing policy measures to exploit the synergies and minimize the trade-offs between the three objectives of climate-smart agriculture. However, some trade-offs may have to be accepted and possibly compensated for when achieving synergies is not possible. Before designing new climate-smart agriculture policies, policy makers should systematically assess the intended and unintended effects of a wide range of current international and national agricultural and non-agricultural agreements and policies on climate-smart agriculture objectives, and take into account other national development priorities. New policies to stimulate the adoption of climate-smart agriculture systems should focus on filling policy gaps and contribute to a country-driven approach to capacity development in the short and long term. Understanding the socio-economic and gender-differentiated barriers and incentive mechanisms that determine the adoption of climate-smart agriculture practices is also critical for designing and implementing supportive policies.

3. Strengthening national and local institutions

Enabling institutions (e.g. financial institutions, land tenure regimes, institutions regulating customary law, community-based organizations, insurance schemes, information and extension services) are essential for harnessing the evidence base to empower, enable and motivate farmers to adopt climate-smart agriculture practices. Cross-sectoral dialogues, which form an important part of the climate-smart agriculture methodology, enhance coordination between institutions dealing with agricultural, climate change, social protection, food security and other issues at the local, national and international levels. These dialogues can take the form of dedicated workshops to consider emerging policies, or presentations and discussions among standing committees or public sector bodies involved in policy formation. In some cases, efforts also need to be made to build the capacities of national policy makers to participate in international policy fora on climate change and agriculture, and reinforce their engagement with local government authorities.

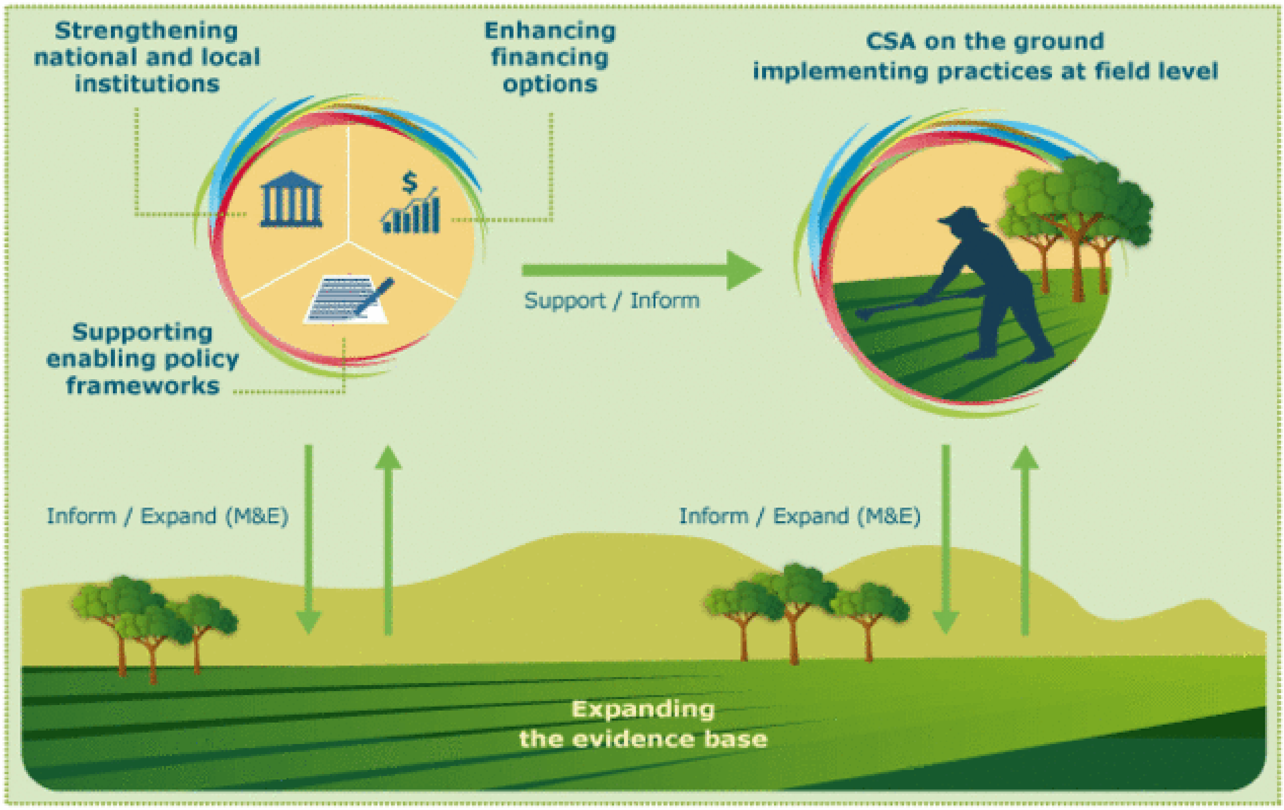
4. Enhancing financing options

Innovative financing mechanisms that improve the links between climate finance and agricultural investments from the public and private sectors are central to implementing climate-smart agriculture. New climate financing mechanisms, such as the Green Climate Fund, may be a way of spurring sustainable agricultural development. Strong Nationally Appropriate Mitigation Actions (NAMAs) and National Adaptation Plans (NAPs) and National Adaptation Programmes of Action (NAPAs), are key national policy instruments for creating links to national and international sources of finance. National sector budgets and official development assistance will continue to be the main sources of funding. Integrating climate change issues into sector planning and budgeting is a prerequisite for successfully addressing the impacts of climate change. Linking climate finance to agricultural investments requires the capacity to measure, report and verify that interventions that have received funding are indeed generating adaptation and mitigation benefits. An evidence base for climate-smart agriculture can provide much of the information needed for making this link.

5. Implementing practices in the field

Farmers, pastoralists, foresters and fisherfolk are the primary custodians of knowledge about their environment, agricultural ecosystems, crops, livestock, forests, fish and local climatic patterns. Efforts to adapt a climate-smart agriculture approach to a specific setting must take into account local producers' knowledge, requirements and priorities. Local project managers and institutions can engage with agricultural producers to identify suitable climate-smart agriculture options that can be easily adopted and implemented. An example of this is the work done through Farmer Field Schools in the United Republic of Tanzania.

Figure A1.1. Schematic representation of the climate-smart agriculture approach



Climate-smart agriculture implementation in agricultural production systems and food systems

Climate-smart crop production

For each crop system, there are countless climate change adaptation and mitigation options that can sustainably improve yields and minimize the harmful environmental impacts of production. They will differ for each farming household, depending on its coping and adaptive mechanisms. Management practices and technologies for climate change adaptation and mitigation include practices with an explicit focus on adaptation and practices with a broader scope on reducing production risks and reducing emissions. Specific climate-smart approaches to crop production include:

- increasing diversity and complexity within the agricultural ecosystem, which can be done in many ways (e.g. expanding the diversity of crops or crop varieties), at many spatial scales (e.g. landscape level, within farms, and/or within the same crop) and over different timeframes;
- improving sustainable soil and land management (e.g. carefully channelling the expansion of crop and grazing land to mitigate the loss of carbon storage that results from land-use change);
- increasing energy use efficiency;
- promoting sustainable mechanization (e.g. increasing the availability of suitable machinery in combination with proper agronomic management to reduce greenhouse gas emissions from various farm and processing operations); and
- developing simple and robust scientific tools to guide the decision-making of farmers on a seasonal and long-term basis.

Climate-smart livestock production

Livestock are an important resource for both developing and industrialized societies. They provide multiple benefits including food, clothing, fuel, draught power, income and employment. They also contribute to nutrient cycling in the soil, and can represent a type of insurance for small-scale producers in developing countries that can safeguard food and income in the event of climate- and weather-associated crises. Livestock production systems are also significant in that they occupy almost one-third of the global ice-free terrestrial land surface, and utilize around 60 percent of the global biomass harvest. Over the coming decades, climate change will affect the natural resource base on which livestock production depends. In many regions, livestock production systems represent the only viable system of food production, and enable communities to inhabit, and prosper in, arid and semi-arid regions. Many of the world's poorest people rely on livestock production for their survival. Climate change presents a range of challenges for livestock producers. Livestock production will be directly affected by changes in temperature and water availability. Climate change will also affect livestock production through it impacts on the supply and quality of pasture and forage crops, the production and prices of feed grains, and modifications in the distribution ranges of livestock diseases and pests. Livestock is also responsible for 14.5 percent of anthropogenic greenhouse gas emissions. Although associated with relatively high greenhouse gas emissions, livestock can reduce the vulnerability to climate change risks for millions of poor livestock keepers. Livestock production systems accounts for up to half of the technical mitigation potential of the AFOLU sectors. This potential can be realized through management options that sustainably intensify livestock production, promote carbon sequestration in rangelands and reduce emissions from manure. A reduction in consumer demand for livestock products can also contribute to climate change mitigation.

Climate-smart fisheries and aquaculture

The fisheries and aquaculture sector is where climate change is expected to have some of the greatest impacts on productivity and livelihoods. Climate-smart agriculture interventions for this sector has focused on adaptation strategies, especially for the most vulnerable populations in small island developing states and coastal communities. In this sector, the major impacts of climate change include severe weather events, increased flooding in coastal and riparian zones, sea level rise, shifts in the distribution range of important species and ocean acidification. The fisheries and aquaculture sector also has the capacity for increasing carbon removal from the atmosphere through farming of seaweeds and improved coastal management (e.g. the protection and management of mangrove forests and estuaries). Healthy ecosystems and sustainable use of fisheries and aquaculture resources are the foundation of climate change adaptation and mitigation for the fisheries and aquaculture sector. The ecosystem approach to fisheries and aquaculture provides the needed framework to holistically address climate change across marine and coastal ecosystems. Climate-smart agricultural strategies that capture fisheries can adopt to lower emissions include reducing fuel use in the global fishing fleet, reducing overcapacity and reducing the carbon imprint of the international trade in fish and fisheries products, which are the most highly traded food commodity.

Integrated production systems

Integrated production systems use some of the products, by-products or services of one production component as inputs for another production component within a single farming operation. In integrated systems, the production components are mutually supportive and mutually dependent. Integrated production systems include agroforestry, crop-livestock, rice-fish, fish-livestock and food-energy systems, as well as less widespread systems, such as aquaponics. By optimizing efficiency in the use of resources, integrated production systems can achieve the synergistic objectives of climate-smart agriculture. The high efficiency in recycling resources (e.g. converting waste into biogas) creates a system with minimum environmental impact and lowers operating costs, as there is less need for inputs (e.g. fertilizer, feed and energy). The diversification of resources and incomes associated with integrated production offers farmers a greater number of risk management strategies and options to adapt to the impacts of climate change. Moreover, the emissions intensities of integrated systems are typically lower than those of specialized systems. However, successful integration rests on the flexibility to reduce trade-offs and competition between the various production components of the agricultural system, which demands substantial technical knowledge, labour, and sometimes upfront investments that will only pay off over a relatively long period of time. Sustainable production intensification from integrated agricultural systems requires a clearer understanding of the impacts of changes in climate and climate variability on these systems.

Water management for climate-smart agriculture

As water plays a crucial role in food production and the management of ecosystems, water management is a critical component of climate-smart agriculture strategies. The implementation of adaptation and mitigation options in water management for agriculture requires an understanding of the potential impacts climate change will have on water resources and the vulnerability of rural populations to these impacts. The agriculture sectors, which are responsible for 70 percent of total freshwater withdrawals globally, are the main users of water resources. Observed data and climate projections show that changes in water quantity and quality due to climate change are expected to compromise food security and increase the vulnerability of poor rural producers, especially in arid and semi-arid areas. The adverse impacts of climate change on freshwater resources will exacerbate the impacts of non-climatic factors, such as population growth, economic development, land-use change and urbanization. These factors are driving changes in water use at a much faster pace than climate change. Water demand will grow in the coming decades, primarily due to population growth and economic development. Changes in irrigation water demand are also expected. Climate change will also affect the design and operation of water infrastructure. Climate change adaptation options for water management will necessarily combine policies, institutions, investments, crop and water management practices and capacity development.

Sustainable soil and land management for climate-smart agriculture

The impacts of climate change will contribute to land and soil degradation and reduce the productivity of these natural resources. However, there are immense opportunities to lessen the negative impacts of climate change on land and soil resources and optimize the potentially positive effects of climate change. This can be done by implementing targeted and adapted sustainable soil and land management practices and selecting the most appropriate land-use systems for a given environment. Sustainable soil and land management encompasses options that allow different user groups to manage their resources, including water, crops, livestock and associated biodiversity, in ways that are best suited to the prevailing biophysical, socio-economic and climatic conditions. Understanding the drivers of change and their impacts (i.e. why the soil and land resources are under risk), is vital for enabling various land users to select and put in practice the most efficient, affordable and acceptable solutions. Land resource planning is an essential entry point and process to choose the most suitable land-use systems for accommodating the often competing uses of land. It can also promote the adoption of locally adapted sustainable soil and land management practices and enable decision-makers and communities to put in place more resilient land-use systems that can support climate change mitigation and adaptation. Successful implementation of sustainable soil and land management options requires an enabling environment that can help enhance technical knowledge in ways that build on modern science and local expertise, and contribute to overcoming the financial, institutional and communication barriers that hinder the wider adoption of climate-smart agriculture.

Conservation and sustainable use of genetic resources for climate-smart agriculture

Genetic resources for food and agriculture are the foundations of sustainability, resilience and adaptability in production systems. Genetic diversity ensures that aquatic species, crops, livestock breeds, forest trees and other woody plant species, micro-organisms and invertebrates can thrive or persist under a range of environmental conditions. It also allows these resources to cope with pests and diseases. More crucially, genetic diversity is a prerequisite for adaptation and continued evolution of the species, varieties and breeds. Climate change is considered as one of the main threats to genetic resources for food and agriculture, and it is expected to bring challenges to both their conservation and use. However, depending on the geographical location, climate change can also create opportunities. There is a need to enhance conservation and sustainable use of genetic resources for food and agriculture and gather more and better information on these resources. Traditional and novel uses of genetic resources can increase the adaptability, resilience and yield of production systems and enhance their contribution to climate change mitigation. It is necessary to raise awareness about the important role genetic resources play in climate change adaptation and mitigation, and strengthen national capacities to sustainably manage their genetic resources.

Management of energy in the context of climate-smart agriculture

Energy is needed for every stage in the food chain, but can also be produced from food chains. The linkages between energy and food production have changed and grown stronger over time. The current use of energy in food systems remains however unsustainable. The food sector currently accounts for around 30 percent of the world’s total end-use energy consumption, and more than 70 percent of the energy used in food chains is consumed beyond the production stage. Most of this energy coming from fossil fuels, the energy used in food chains accounts for more than one-third of the total emissions from food chains. To address the challenges of climate change, the development of food chains can no longer rely on such a high level of dependency on fossil fuels. This requires to scale up energy-smart food chains, relying on adequate access to modern energy services through (i) improved energy efficiency, (ii) increased use and production of renewable energy, (ii) sustainable bioenergy, and (iv) a water-energy-food nexus approach that connects the use and consumption of water, energy and food.

Developing sustainable food systems and value chains for climate-smart agriculture

Climate-smart agriculture approach are required in the entire value chain from production to consumption. It is important to take a holistic, systems view of climate impacts and vulnerabilities to identify climate-smart interventions to adapt to and mitigate climate change, where possible, to work towards sustainable food systems. FAO’s sustainable food value chain development (SFVCD) approach uses systems thinking to identify leverage points for proactive interventions that will have sustainable positive impacts, including greening the value chain for climate-smart agriculture. The SFVCD approach involves an analysis of three interconnected levels: the core value chain (i.e. the stages from production to disposal), the extended value chain including support services, and the enabling environment – both societal and natural elements. By analysing the diverse actors and their interlinked value-adding activities from ‘farm to fork’, including the production, aggregation, processing, distribution, consumption and disposal of products that originate from agriculture, forestry or fisheries, and the environments in which they are embedded, it is possible to identify interventions at all levels for sustainable value chains and food systems. Interventions for climate adaptation and mitigation to “green” value chains at all levels - both core and extended, and to improve the enabling environment for sustainable and green value chains include investments in infrastructure (e.g. storage, roads) and packaging; efforts to reduce food loss and waste; optimising energy and input usage; implementing policies; and generating knowledge for all actors to influence behaviour change in the value chain and food systems (e.g., reducing consumption and improving extension services).

Enabling environment for climate-smart agriculture: policies, institutions and finances

Scaling up climate-smart agriculture to trigger the desired transformation in agricultural production systems and food systems requires supportive policies, institutions and financing, that together create an enabling environment for climate-smart agriculture at local, national and international levels. Changes in production that might be expected based on certain climate indicators may not occur due to other factors related to human capital (e.g. level of education, age, ethnicity, gender of producers), economic conditions (e.g. relative prices, input and output market development, credit availability) and the policy environment (Bradshaw *et al*., 2004; Asfaw *et al*., 2015; Arslan *et al*., 2015). The response of agricultural producers to climate change and variability will depend on the socio-economic position of the household. Poor farmers are likely to take measures to ensure their survival, while wealthier farmers make decisions to maximize profits (Ziervogel *et al*., 2005; Asfaw, Maggio and Lipper, 2016). For this reason, the impacts of climate change are expected to affect different segments of the rural population differently. At the same time, a wide diversity of responses to these impacts can be expected given the differences in the socio-economic characteristics of different households and communities.

A1-4.1 Role of policies for climate-smart agriculture

Recently, several important international agreements have been reached that will shape national climate-smart agriculture planning and implementation. The 2030 Agenda for Sustainable Development will serve to guide national development plans over the next 15 years. There are three components of the 2030 Agenda for Sustainable Development: the SDGs, which set the global policy framework; the Paris Agreement on climate change; and the Addis Ababa Action Agenda, which identifies the broad set of financial and non-financial means for implementation the agenda. In all of these components, agriculture is prioritized as a crucial sector to ensure that the needs of both the people and the planet are met.

The Paris Agreement recognizes "the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse effects of climate change". A series of instruments –NAPAs, NAPs and NAMAs – have been designed under the UNFCCC for linking international climate change contributions (including those made in the INDCs) to concrete national mitigation and adaptation actions. A principle common to all these instruments is that adaptation and mitigation measures should not be considered in isolation from other climate and development goals.

The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 builds on the experiences of the Hyogo Framework for Action (2005-2015) and recognizes disaster risk reduction as important part of attaining sustainable development and addressing climate change. The Framework addresses climate change as one of the drivers of disaster risk and highlights the fact that linkages with the 2030 Agenda for Sustainable Development and the Paris Agreement represent a unique opportunity "to reduce disaster risk in a meaningful and coherent manner across policies, institutions, goals, indicators and measurement systems for implementation".

At the national level, making the transition to climate-smart agriculture requires not only strong political commitment but greater coherence, coordination and integration among the various sectors dealing with the drivers that are influencing climate change, agricultural development, and food and nutrition security. In this regard, the development of enabling policies and the promotion of an adequate regulatory and legislative environment is crucial. Increasing policy coherence calls for a systematic assessment of current policies and their intended and unintended effects on the set of development objectives prioritized by a country, including those pertaining to climate-smart agriculture. Public policies, as well as expenditure and planning frameworks, should work toward an integration of new climate-smart agriculture policies and support measures at the national, subnational and local levels. Representatives from the entire range of stakeholder groups involved in all sectors and at all levels need to participate fully in this coordination and integration process. To ensure that the benefits of these activities are shared equally it is important for the process to be gender-inclusive. It is also critical to recognize the value of indigenous knowledge and farming practices, and engage with representatives from indigenous organizations when developing coherent cross-sectoral policy frameworks. Depending on the country, the priority among the climate-smart agriculture objectives may vary. Nevertheless, it is important to identify and enhance synergies between the different policy objectives and address and compensate for trade-offs where necessary. Understanding the local and gender-specific barriers and incentive mechanisms for adoption of climate-smart agricultural production systems is key for designing supportive policies.

The public sector can play a key role in creating an enabling policy and legal environment for climate-smart agriculture, which can permit private sector and civil society stakeholders to make timely, well-informed and efficient decisions related to securing food production, adapting to climate change and reducing and removing greenhouse gases. Many stakeholders, especially smallholder agricultural producers with limited assets will only be inclined and able to take necessary actions if their work is enabled by a coherent climate-smart agriculture policy framework. The transition to climate-smart agriculture requires transcending sectoral and other boundaries and calls for the full integration of climate change issues into the policy-making process at all levels. This means that new institutional structures and alliances among private and public stakeholders in a range of different areas, including policy making, research, extension and financing may be needed.

A1-4.2 The role of institutions

The ability of agricultural producers to adapt to climate change requires that rural communities have access to up-to-date information, inputs (e.g., fertilizers and machinery) and a diverse set of genetic resources for food and agriculture (e.g., locally adapted seeds and planting materials, livestock and fish stocks). Increasing the returns and benefits that agricultural producers derive from their production systems, which is an essential component of climate-smart agriculture, will demand well-functioning and accessible output markets. To accomplish this, innovative approaches to establishing and strengthening formal and informal institutions may be needed to bolster local resilience, support livelihood diversification strategies and reinforce coping strategies. Producers need to have the correct incentives and enabling conditions to make transformations on the ground, which need to be facilitated by institutions and policies. This effort must involve all stakeholders, producers, agro-industrial enterprises, retailers, consumers and public authorities.

A1-4.2.1 Access to information

One of the key constraints to the widespread adoption of climate-smart agriculture concerns the flow of information and knowledge. Information on the range of climate-smart agriculture options, particularly those well suited to local conditions, is often scarce. For example, inadequate information can increase the risk of planting expensive seeds that may not survive or produce poor yields (Ajayi *et al.*, 2007; Franzel *et al*., 2004; Asfaw, Di Battista and Lipper, 2014; Asfaw *et al*., 2015). Information available to producers on climate-smart agriculture options that are well adapted to their particular setting is likely to be an important determinant for adoption. Information may come from a number of sources, including government extension programmes, non-governmental organizations and donor programmes.

Based on the abundant evidence that seasonal climate variability plays an important role in the risks faced by producers, it is natural to conclude that the foundation for building adaptive capacity of rural communities is knowledge management. Increasing access to reliable information is crucial to facilitating adaptation as it can improve the decision-making capacities of producers with regard to their farming systems. One key role of institutions is the production and dissemination of knowledge and information, which can range from the impacts of climate change on production and marketing conditions, to the development of regulations and standards.

Climate change increases uncertainty. This fact makes it all the more important for agricultural producers to able to respond rapidly and appropriately to unexpected phenomenon, and understand the potential costs of inaction. This situation greatly increases the value of information and the importance of institutions that are engaged in conducting agricultural research, providing extension services, collecting and analysing agricultural production and marketing statistics and disseminating climate-related information (Campbell *et al*., 2011).

When adopting climate-smart agriculture practices producers must make both short- and long-term decisions about their management plans and the technology they will use. Agricultural extension systems are the main conduit for disseminating the information required to make these decisions. However, problems are often encountered in providing information at a relevant spatial scale and timeframe, communicating this information so that it reaches those who need it most, and promoting the participation of the users of this information in the development of effective information systems (Hansen *et al*., 2007; Arslan *et al*., 2015; Asfaw and Lipper, 2016).

A1-4.2.2 Access to micro-finance and insurance

Adopting climate-smart agriculture practices requires that producers make increased investments that extend over a relatively long period of time. McCarthy *et al*. (2011) have documented the extended transition times needed to realize the benefits of climate-smart agriculture in the terms of productivity or increased resilience. During the transition, the returns to agriculture can be low or negative, and thus some form of financing to support this transition is necessary. This transition cost is likely to be higher for poorer producers, which makes the challenge of delivering the benefits of climate-smart agriculture to those most in need even greater (McCarthy *et al*. 2011). The capacity of producers to make the required adjustments depends in large part on the existence of policies and institutions that can support their access to credit and insurance.

The adoption of climate-smart agriculture practices, such as conservation agriculture, encounters most of the traditional constraints that other innovative production practices also face (McCarthy *et al*., 2011). As with any new methods or technologies, climate-smart agriculture practices may be perceived as a risky investment, as farmers will need to learn new farming methods and typically do not have access to insurance. Credit constraints will also affect adoption, especially when initial investment costs are high and the benefits of the practices are usually realized after around four years. Just how binding cash constraints are is obscured by the fact that many projects promoting climate-smart agriculture practices provide inputs, such as seeds and seedlings, for free, particularly in East and Southern Africa (Franzel *et al.*, 2004; Asfaw, Di Battista and Lipper, 2014; Arslan *et al*., 2015). Nonetheless, a number of empirical studies have found that wealthier households with greater landholdings are more likely to adopt climate-smart agriculture practices, such as agroforestry. This indicates that cash constraints and opportunity costs of land in the near term are likely to affect producers' decisions to adopt climate-smart agriculture practices (Phiri *et al*., 2004; Kuntashula *et al*., 2002; Asfaw and Maggio, 2016b).

A1-4.2.3 Access to agricultural input and output markets

The decisions agricultural producers make about the type of technologies and practices they adopt are determined by their benefits and costs, which are affected by the access these producers have to supplies of inputs and output market chains. Improved market access, which increases the returns on land and labour, is a critical factor for the adoption of new climate-smart agriculture practices. However, many smallholders in vulnerable areas continue to face complex challenges in adoption of climate-smart agriculture practices. There is still limited understanding of how inadequate markets, policies and institutions shape and structure producer incentives and investment decisions.

Addressing these overlapping constraints requires innovative institutional arrangements and partnerships that improve the local availability and utilization of climate-smart agriculture inputs and create effective market linkages that offer more stable and better prices to producers. Producer organizations have the potential to mitigate the effects of imperfect markets by establishing contractual links to input and output markets and promoting economic coordination in liberalized markets, which can leverage market functions for smallholder farmers (Shiferaw and Hailemariam, 2007). This can be expected to stimulate adoption of climate-smart agriculture practices, which will in turn drive the process of agricultural commercialization in rural areas.

Realizing the potential of climate-smart agriculture will depend on the ability of institutions to convey market information, coordinate production and marketing functions, define and enforce property rights and contracts and, more critically, mobilize producers to participate in markets and enhance the competitiveness of agro-enterprises. Institutions, which provide multiple functions to markets, can transmit information, mediate transactions, facilitate the transfer and enforcement of property rights and contracts, and manage the degree of competition. These activities provide alternative mechanisms through which market failures in rural areas can be remedied (Shiferaw and Hailemariam, 2007).

A1-4.3 Investments and financing

Agricultural investment is one of the most important and effective strategies for promoting economic growth and reducing poverty in rural areas where the majority of the world’s poor live. Gross domestic product (GDP) growth in agriculture has been shown to be at least twice as effective in reducing poverty as growth originating in other sectors (World Bank, 2008). The regions of the world where hunger and poverty are most widespread today have seen stagnant or declining rates of investment in the agriculture sectors over the past three decades. Eradicating hunger in these regions and increasing food production requires substantial increases in the level of investment in the agriculture sectors. This includes dramatic improvements in the level and quality of national government domestic investment. FAO estimates that an additional investment of USD 83 billion will be needed annually to close the gap between what low- and middle-income countries have invested each year over the last decade and what is needed by 2050. In other words, yearly investment in agriculture needs to rise by more than 50 percent.

These investment requirements are even greater when the need to address the impacts of climate change is taken into consideration (FAO 2010a; Nelson *et al*., 2010; HLPE, 2012a). However, access to sufficient and adequate finance for the agriculture sector has been a challenge in developing countries for decades. Traditionally, agriculture’s share in the investment portfolios of financial institutions has been small, especially compared to agriculture’s contribution to GDP. Because the agriculture sectors are considered low-profit and high-risk, financiers in most countries limit their exposure, charge higher interest rates, tighten lending criteria, shorten terms and impose onerous lending conditions. They often shy away from lending to agriculture altogether, preferring to seek more stable returns from other sectors of the economy, such as trade, housing and energy. The resulting shortfall in finance has a severe impact on agriculture, including smaller producers and both small- and medium-sized agribusinesses. It must be emphasized however that the major part of investments in agriculture will be made by the private sector, mostly by the producers themselves. In 2014, the private sector, which is the largest source of finance for climate change adaptation and mitigation efforts, contributed approximately 62 percent out of a total of USD 391 billion dollars of finance to address climate change (Buchner *et al*., 2015). The amount of this private finance that was allocated to the AFOLU sector is unknown. However, the activities funded by public finance can have a strong catalytic effect, encouraging the mainstreaming of climate change mitigation and adaptation responses into other larger sources of agricultural finance, such as domestic government spending and the producer’s own agricultural investments.

The public sector can play a key role in building an enabling environment, including formulating policies, strengthening institutions and making key investments. Reducing risk and improving resilience is key to enabling private sector stakeholders, especially the more financially vulnerable, to invest. These private sector producers will also need support, particularly during the transition phase towards new systems. Payments for environmental services can play an important role in facilitating this transition (Lipper and Neves, 2011).

Among the needed investments are land management strategies and infrastructure, including local roads and irrigation systems, which are an important source of job creation in rural areas. These public works can be supported by social protection schemes to provide work, food and income to food-insecure people. A report of the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2012b) reviews some of these schemes and concludes that public works programmes have proved to be efficient in dealing with covariate shocks and, if they are well designed, can contribute to improving food security.

Major investments are also needed in research (HLPE, 2012a; Beddington *et al.*, 2012c). To be able to embrace the whole range of issues to be addressed, these investments must be coordinated at the regional and global scale. Increased investment in public research is particularly required in areas where returns on investment cannot immediately benefit the private sector. To address systemic issues related to the development of climate-smart production methods that are specific local needs and conditions, research will have to be closely linked to extension services and be receptive to local knowledge and responsive to the demands articulated by all stakeholders, including small-scale food producers (HLPE, 2012a). In this regard, the transfer of technology will also play an important role. Activities in this area should include the development of the capacities to use the new technology and structured partnerships to ensure that it is suitable adapted to local conditions.

CSA in the broader development agenda

Climate smart agriculture is a new approach for charting a pathway to develop agricultural systems that promote sustainability, strengthen food security and combat climate change. Climate-smart agriculture shares the guiding principles of the 2030 Sustainable Development Agenda, the SDGs and the objectives of the green economy. Climate-smart agriculture is fully aligned with the five principles of the FAO vision for sustainable food and agriculture, which was developed as part of the Organization's contribution to the 2030 Agenda for Sustainable Development (FAO, 2014a; FAO, 2016b). This section aims at clarifying how climate-smart agriculture positions itself in the broader development agenda and how it relates to other concepts and approaches.

A1-5.1 The 2030 Agenda and the Sustainable Development Goals

As indicated earlier, the 2030 Agenda for Sustainable Development and the 17 SDGs will serve to guide national development plans over the next 15 years. The agriculture sectors lie at the heart of the 2030 Agenda for Sustainable Development. The SDGs, which were agreed on by United Nations member states, constitute a complex set of priorities, and associated means of implementation. They are broken down in 169 concrete targets that will be measured through a set of indicators. Poverty and hunger remain top priorities for the agenda. The stated goal now is the complete eradication of hunger and poverty, which represents a significantly more ambitious aspiration than the earlier Millennium Development Goal, which was to halve, between 1990 and 2015, the proportion of people who suffer from hunger. SDG2, 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture', makes it clear how important the promotion of sustainable agriculture, rural development, and the sustainable use and management of natural resources is to the 2030 Agenda for Sustainable Development. SDG Target 2.3 gives special attention to the role and needs of small-scale food producers, as a priority target group for intervention. The rights of small-scale producers, women, indigenous peoples and youth to have access to resources are reflected throughout the entire 2030 Agenda for Sustainable Development. SDG Target 2.4 calls for more sustainable food systems; the implementation of resilient agricultural practices that increase productivity and production; and the responsible management and use of resources to maintain ecosystems, strengthen capacities to adapt to climate change, extreme weather, drought, flooding and other disasters, and progressively improve land and soil quality.

To support global efforts to implement the 2030 Agenda for Sustainable Development, FAO (2014a) has developed a common vision and approach for sustainable food and agriculture (SFA). Building on extensive work that promotes sustainability in various production systems, the approach identifies five principles that balance the social, economic and environmental dimensions of sustainable food and agriculture, and provide the basis for developing policies, strategies, regulations and incentives that are in line with the 2030 Agenda for Sustainable Development (see Box A1.2).

Box A1.2 Five principles for sustainable food and agriculture (FAO, 2014a)

1. Improving efficiency in the use of resources – This includes the use of natural resources, energy external inputs, and labour. Modifying current practices can do much to improve the productivity of many food and agricultural production systems.
2. Direct action to conserve, protect and enhance natural resources – Food and agricultural production depends on natural resources and therefore the sustainability of production depends on the sustainability of the resources themselves. Much can be done to reduce negative impacts and enhance the status of natural resources.
3. Protect rural livelihoods and improve equity and social well-being - Ensuring that producers have adequate access to and control of productive resources, and addressing the gender gap, can contribute significantly to reducing poverty and food insecurity in rural areas.
4. Enhance the resilience of people, communities and ecosystems, especially to climate change and market volatility - Extreme weather events, market volatility and civil strife impair the stability of agriculture. Policies, technologies and practices that build producers' resilience to threats would also contribute to sustainability.
5. Responsible and effective governance is essential for the sustainability of both the natural and human systems - This includes policies and strategies that are consistent across sectors, alignment of legal frameworks and investments, and strengthening of capacities of institutions and relevant stakeholders at all levels. It is based on stakeholder dialogue, partnerships, and the application of mechanisms aimed at building consensus around sustainable development objectives.

Climate-smart agriculture is an integral part of the sustainable food and agriculture approach. It shares its principles, and seeks to promote sustainable agriculture through the three dimensions of sustainability, with specific focus on climate. For this reason, climate-smart agriculture has also been considered a key element in achieving many of the SDGs.

The 17 SDG goals are complex, multidimensional and closely interlinked. By design, the 2030 Agenda for Sustainable Development calls upon member states and their partners to explore the linkages across goals and targets, develop synergies and address the trade-offs that arise from them. Consequently, climate-smart agriculture has the potential to not only help achieve SDG2, but many of the other SDGs as well, including:

- SDG1 'End poverty in all its forms everywhere';
- SDG6 'Ensure access to water and sanitation for all';
- SDG 8 'Promote inclusive and sustainable economic growth, employment and decent work for all';
- SDG12 'Ensure sustainable consumption and production patterns';
- SDG13 'Take urgent action to combat climate change and its impacts';
- SDG14 'Conserve and sustainably use the oceans, seas and marine resources'; and
- SDG15 'Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss'

There is ample evidence from local initiatives and experiences demonstrating how climate-smart agriculture is empowering households and communities to directly and concretely realize the SDGs. Climate-smart agriculture, which is guided by the need for more resource efficiency and resilience, brings together global and local concerns in addressing climate change adaptation, mitigation and at the same time achieving food security. To do so it brings together practices, policies and institutions, which are not necessarily new. What is new in climate-smart agriculture is the acknowledgement that agriculture needs to address multiple challenges. This requires dialogue, and a harmonization and synchronization of practices and policies that focus on avoiding contradictory and conflicting actions by managing trade-offs and synergies in the pursuit of multiple objectives.

A1-5.2 Links between climate-smart agriculture and other initiatives and concepts

A1-5.2.1 Green Economy

In its Green Economy Report, the United Nations Environment Programme (UNEP) defined the green economy as "An economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2010). A green economy is one whose growth in income and employment is driven by investments that simultaneously reduce carbon emissions and pollution; enhance efficiency in the use of energy and natural resources; and prevent the loss of biodiversity and ecosystem services. Green economy objectives are clearly aligned with the 2030 Agenda for Sustainable Development. As stated in the outcome document of the Rio + 20 conference the "green economy in the context of sustainable development and poverty eradication will enhance our ability to manage natural resources sustainably and with lower negative environmental impacts, increase resource efficiency, and reduce waste." (United Nations, 2012).

Agriculture plays an essential role in moving towards a green economy. There can be no green economy without a 'greener' agriculture. This is why FAO proposed 'Greening Economy with Agriculture' as the basis key message for Rio+20 (FAO, 2012). Associated with the green economy is the concept of green growth. Originating in the Asia and Pacific Region in 2005, green growth initiatives focus on efforts to harmonize economic growth with environmental sustainability and enhance the synergies between environment and economy. The green growth concept has been used by the ministry of environment of several countries to promote better integration between economic and environmental goals.

By explicitly addressing issues of productivity and income, resilience and mitigation, climate-smart agriculture offers a concrete way to move towards a greener economy. It makes sustainable development tangible by focusing on issues that can and must be addressed in local communities but that have global, long-term consequences.

A1-5.2.2 Sustainable Intensification

Sustainable intensification is an important component of strategies to achieve sustainable food and agriculture. It is predicated on the acknowledgement that many countries must increase agricultural production and productivity in a much more sustainable manner than earlier development models. It seeks to raise productivity, lower production costs and increase the level and stability of returns from production, while conserving natural resources, reducing the negative environmental impacts of production and enhancing ecosystem services (FAO, 2011c). The nature of sustainable intensification strategies varies across different types of agricultural systems and locations. However, one of the core principles is increasing the efficiency of resource use. Through better management of carbon and nitrogen cycles, sustainable agricultural intensification also builds greater resilience to the impacts of climate change and contributes to reducing greenhouse gas emissions (Burney *et al*., 2010; Wollenberg *et al*., 2016).

Sustainable intensification and climate-smart agriculture are highly complementary. The FAO approach to sustainable crop production intensification is the 'Save and Grow' model, which promotes a productive agriculture that conserves and enhances natural resources. This model follows an ecosystem approach that draws on nature's contribution to crop growth, such as soil organic matter, water flow regulation, pollination and natural predation of pests. It applies appropriate external inputs at the right time and in the right amount to cultivate improved crop varieties that are resilient to climate change and use nutrients, water and external inputs more efficiently. Increasing resource use efficiency, reducing the use of fossil fuels and reducing environmental degradation are key components of the Save and Grow approach. This can save money for farmers and prevent the environmental damage caused by the overuse of some inputs. This approach, which was developed for crop production, has been extended to other agriculture sectors.

Both the sustainable intensification and climate-smart agriculture also pay particular attention to analysing trade-offs of different options. In sustainable intensification approaches, this may involve the trade-offs between intensification in one part of the landscape or globe, which may increase emissions and have other impacts on land sparing or land cover change in other areas or regions. Trade-off analyses would involve understanding which practice is more beneficial for which objective and in what context; and exploring policy and market mechanisms that enhance sharing or sparing initiatives.

A1-5.2.3 Agroecology

Agroecology applies ecological concepts and principles to farming systems (HLPE, 2016). Through its focus on the interactions between plants, animals, and the environment, and the integration of the different agricultural sectors, it fosters sustainable agricultural development, which in turn ensures food security and nutrition. Agroecology goes beyond input use efficiency and input substitution. It harnesses key ecological processes, such as natural pest predation and the recycling of biomass and nutrients, to enhance the beneficial biological interactions and synergies among the components of agricultural biodiversity. Agroecological principles, as defined by Nicholls, Altieri and Vazquez (2016), are particularly important for climate change adaptation.

Agroecology does not promote a fixed set of farming practices or technologies. It stresses the importance of the specificity of local environmental conditions, and posits that local farming communities are be best placed for identifying functional ecological strategies to improve farming systems. Agroecology was initially focused on building knowledge on the use and value of ecosystem services in agriculture, even though the term 'ecosystem services' was not in use at that time. Agroecology is by nature climate-smart, as it contributes to the three objectives of climate-smart agriculture. Many climate smart projects are implementing practices based on agroecological principles.

A1-5.2.4 Sustainable Food Value Chains

FAO’s sustainable food value chain approach, as elaborated in the publication “Developing Sustainable Food Value Chains-Guiding Principles” (FAO 2014b), places the value chain at the heart of a system of complex environments that determines the behaviour and performance of farms and other agri-food enterprises. SFVC development requires systemic analyses at three inter-connected levels: the core value chain, the extended value chain, and the broader enabling environment. The sustainability of the value chain plays out simultaneously along three dimensions: economic, social and environmental. On the economic dimension, a value chain is considered sustainable if the activities required to be conducted by each value chain actor or support provider are commercially or fiscally viable. On the social dimension, sustainability refers to socially and culturally acceptable outcomes in terms of fair distribution of the benefits and costs associated with the increased value creation. On the environmental dimension, sustainability is determined by the ability of value chain actors to reduce and eliminate negative environmental impacts from their activities; and where possible, they should have a positive impact.

The SFVC approach provides a framework to effectively address food security challenges in the context of climate change. First and foremost, its triple bottom line principle of economic, social and environmental sustainability is directly linked to three pillars of climate-smart agriculture. In fact, there are many similarities between the two approaches. Both approaches focus on increasing productivity, profitability and incomes, as clearly stated in the first pillar of climate-smart agriculture.

The SFVC approach upholds market-based solutions that start from market opportunities, and focuses particularly on how value is captured at end markets. Moreover, it includes a distributional principle, which implies that profits and incomes should be equitably distributed, thereby contributing to building people’s resilience to shocks and variability, which is the second pillar of climate-smart agriculture. One main difference between the two approaches, though, is that SFVC looks at broader environmental impacts (e.g. water footprint, biodiversity, toxicity) rather than only greenhouse gas emissions, as in the third pillar of climate-smart agriculture.Through its emphasis on a multi-layer approach to problem analysis, the SFVC framework can complement climate-smart agriculture to broaden the frame of analysis, expose root causes of the greenhouse gas emissions, and identify the most feasible and critical entry points to adapt to and mitigate climate change. It embraces systems thinking in that rather than looking at isolated value chain functions, such as production or processing, it aims for a holistic understanding of their interactions, feedback loops and how they together affect systems dynamics. Under the SFVC framework, often there are multiple binding constraints to improving value chain performance that do not only lie in chain itself, but also beyond the chain in outer layers such as support services and the wider enabling environment. Last but not least, the SFVC approach calls for integrated interventions along all three aforementioned levels, rather than at each level separately. A major challenge to the adoption of climate-smart agriculture at the national level is the need to overcome sectoral boundaries and enhance synergies while minimizing trade-offs between climate-related and other policy objectives. Through a multi-stakeholder process that employs systems thinking, the SFVC approach helps in moving from reactive to proactive policies, and in mobilizing expertise from different disciplines and stakeholders- both public and private, at local and national levels- in the design and implementation of climate-smart agricultu

Conclusions

Climate change poses a growing threat to sustainable development. The expected effects of climate change could seriously compromise the ability of the agriculture sectors to feed the world, and severely undermine progress toward eradicating hunger, malnutrition and poverty. Action is urgently needed to prepare the agricultural sectors for the prospect of rapidly changing environmental conditions. As the agriculture sectors are partly responsible for the accumulation of greenhouse gas in the atmosphere that are responsible climate change, it is also important to reduce agricultural emissions. Even without climate change, world agriculture and food security are face daunting challenges. Population growth and rising incomes in much of the developing world have pushed the demand for food and other agricultural products to unprecedented levels. Without heightened efforts to reduce poverty and improve agricultural productivity, many low-income countries, especially those in sub-Saharan Africa and South Asia, will find it difficult to ensure access to adequate quantities of food for all.

Agriculture production systems and food systems must undergo significant transformations to meet the interlinked challenges of achieving sustainability, ensuring food security and addressing climate change. Increasing resource efficiency is essential to increase and safeguard food security in the long term and making a significant contribution climate change mitigation. With the increased risks from the impacts of climate change, efficiency and resilience have to be considered together at every scale and from environmental, economic and social perspectives. Climate-smart agriculture is a dynamic approach that guides the needed changes towards addressing the challenges of climate change. It is not a new agricultural system, nor a set of practices. It articulates globally applicable principles for managing agriculture for food security under changing climatic conditions, which can serve as the basis for policy support and recommendations by multilateral organizations. Climate-smart agriculture provides a framework for putting in place comprehensive policies, adequate institutions and proper governance to implement sustainable, climate-sensitive development strategies. The framework can also be used for channelling new financing to address the investment needs for research organizations and enable farmers to overcome the barriers, including up-front costs and temporarily foregone income, to the adoption of climate-smart agriculture practices.

The climate-smart agriculture approach is particularly important for agricultural producers in developing countries who are at risk of food insecurity as a result of climate change and who have limited means, little policy support and few institutions that can help them cope with change. Climate justice demands action to assist these producers who are most affected by climate change but have contributed least to it; and provide opportunities to developing countries to enhance their food security and speed their economic growth. Actions taken to improve food security and help producers adapt to change can often have significant mitigation co-benefits. They may, however, have higher upfront costs. Finding appropriate ways to provide incentives for the uptake of climate smart alternatives is a key priority. In many countries, agricultural policy is inextricably linked with economic support for rural economies. There are an increasing number of possibilities for low-income countries to orientate production along pathways that are both more sustainable and more productive. Research and development partners have a crucial role to play in identifying and promoting climate-smart practices that strengthen rural communities, improve smallholder livelihoods and employment, and avoid negative social and cultural impacts, such as loss of land tenure and forced migration. In many developing countries, the design and implementation of agricultural support policies could be radically improved. The objectives of climate-smart agriculture goals need to be integrated into this broad policy context.

Acknowledgements

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Notes: The module is an update of Module 1 *Why Climate-Smart Agriculture, forestry and fisheries in the Climate-Smart Agriculture Sourcebook* (2013) written by Vincent Gitz (FAO) and Alexandre Meybeck (FAO) with contributions from Reuben Sessa (FAO, Richie Ahuja (EDF-India), Kevern Cochrane (FAO), Anette Engelund Friis (World Farmers Organization), Elwyn Grainger-Jones (IFAD), Hsin Huang (OECD), Chang-Gil Kim (KREI South Korea), Atta-Krah Kwesi (Bioversity International), James Lomax (UNEP), Dr B. Mantlana (South Africa), Hayden Montgomery (New Zealand), Lucia Perugini (University of Perugia) and Dipti Thapa (World Bank), and reviewed by Wilfrid Legg and Shivaji Pandey.

Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use
GDP	gross domestic product
HLPE	High Level Panel of Experts on Food Security and Nutrition
INDS	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plans
NAPA	National Adaptation Programmes of Action
SDGs	Sustainable Development Goals
SFVCD	Sustainable food value chain development
UNDP	United National Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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