C10 The theory of change for the CSA approach: a guide to evidence-based implementation at the country level

Overview

This module articulates a theory of change for climate-smart agriculture. The theory of change serves as a foundation for a step-by-step guide for implementing a national climate-smart agricultural strategic framework. The first section of the module describes the elements of the theory of change. Based on this theory, the second section lays out the steps that need be followed to establish the required evidence base to support climate-smart agriculture planning and implementation. These steps are associated with five distinct activities: stocktaking of challenges and options; identifying potential climate-smart agriculture interventions; expanding the evidence base for climate-smart agriculture objectives; assessing barriers to adoption; costing interventions; and prioritizing and planning for country-owned climate-smart agriculture strategies. The third section highlights some of the key capacities that need to be developed to build and sustain a national climate-smart agriculture strategy and integrate climate-smart agriculture into policies that extend beyond specific projects and programmes.

Key messages

- Robust evidence, multistakeholder dialogue, accessible tools and methodologies, system-wide capacity development and partnership building are at the core of the theory of change for integrating climate-smart agriculture approaches into policy making at the national level.
- Assessing intervention options for their potential contributions to the achievement of climate-smart agriculture's interlinked objectives demands the accumulation of what can appear to be a daunting amount of evidence. However, many tools and methodologies are available and many more are being developed to assist countries in prioritizing climate-smart agriculture interventions.
- Costing interventions, including the costs of inaction under various climate scenarios, is an important tool

for the prioritization of climate-smart agriculture interventions.
- Climate-smart agriculture interventions can be undertaken at multiple levels, and assessments need to consider a diverse range of locations and timescales to ensure the coherence of national climate-smart agriculture strategic frameworks.
- To facilitate the transition to climate-smart agriculture, system-wide and needs-based capacity development is required in four key categories: information management, research, stakeholder processes, and evidence-based decision-making.

Introduction

Climate-smart agriculture is a broad approach with ambitious goals that involve a diverse spectrum of sectors, stakeholders and disciplines, and cover a wide range of locations and timescales. For this reason, making the transition to climate-smart agriculture requires changes at many levels of policy making. To facilitate the needed changes, this module lays out a step-by-step guide to support the implementation of the climate-smart agriculture approach. The steps in the guide accommodate the site-specific nature of the climate-smart agriculture interventions and helps maximize synergies and reduce trade-offs among climate-smart agriculture's three objectives: sustainably increase agricultural productivity and food security; support the adaptation of vulnerable agricultural communities to the impacts of climate change; and, where possible, remove or reduce greenhouse gas emissions. The step-by-step process described in this module also can help harmonize activities carried out at the different levels of climate-smart agriculture interventions from the field level to the national policy level.

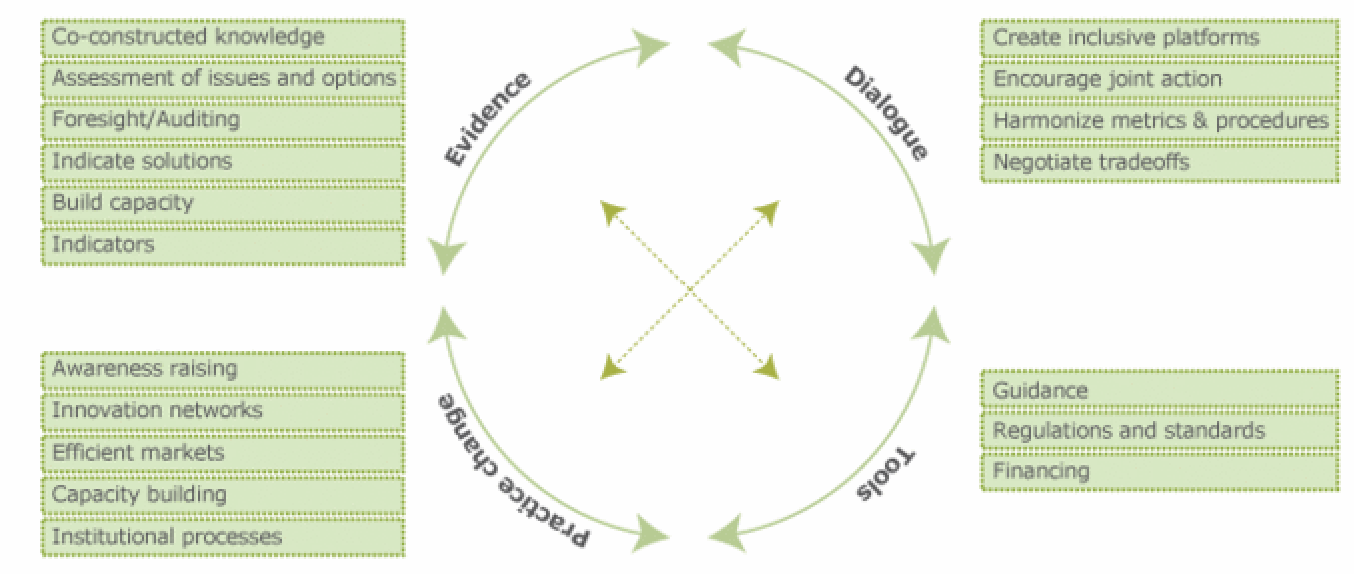
Other modules in this sourcebook have documented the challenges climate change poses to the agricultural sectors and highlighted options that can contribute to the objectives of climate-smart agriculture in various settings. Rather than discussing the steps for designing and implementing projects and policies to promote these interventions, this module develops a theory of change for the climate-smart agriculture approach and describes an overarching set of steps that need to be taken to implement it in national policy making. Climate-smart agriculture activities, which have been selected based on sound empirical evidence, can be implemented at the local level (e.g. the promotion of agroforestry), the national level (e.g. the delivery of local and timely weather forecasts) or the regional level (e.g. the transboundary management of key natural resources, such as water bodies and forest catchment areas). The steps outlined in this module encompass all these levels to ensure the needed reorientation of policy making for making a transition to climate-smart agriculture.

Climate-smart agriculture 101, published by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) has set out a four-step approach to the development of a climate-smart agriculture plan including situation analysis, targeting and prioritization, programme support and monitoring, evaluation and learning. These four steps are a subset of the steps discussed in detail in this module. This module expands the scope of the CCAFS climate-smart agriculture guide to cover all sectors at multiple levels and provides additional detail on the available tools for capacity development and partnership building.

C10 - 1.1. Theory of change for climate-smart agriculture

Climate-smart agriculture is embedded in the pursuit to achieve sustainable food and agriculture. Reaching this goal requires activities in four broad areas of action: (i) the creation of an evidence base to motivate, support and monitor change; (ii) continuous dialogue with stakeholders; (iii) formulation of tools to enable change; and (iv) innovative approaches to create and sustain change in food and agricultural systems (FAO, 2014). (see Figure C10.1). This module's step-by-step guidance for implementing climate-smart agriculture, as conceptualized in the theory of change, is based on these four broad areas of action.

Figure C10.1. Four areas of action for sustainable food and agriculture



Source: FAO, 2014

The theory of change for the implementation of climate-smart agriculture featuring these four areas of action is illustrated in Table C10.1. Other modules of this sourcebook, particularly module A.1, have described the origins of climate-smart agriculture and the challenges it seeks to address. The problem statement for climate-smart agriculture can be articulated as: "climate change is threatening agriculture's ability to feed a growing global population and provide the basis for economic growth and poverty reduction." The main challenge to be addressed by climate-smart agriculture is the need to transform agriculture production systems and food chains to so that they sustainably increase agricultural productivity and incomes; support the adaptation of vulnerable agricultural communities to the impacts of climate change; and, where possible, remove or reduce greenhouse gas emissions. Activities to bring about the needed transformational change are grouped under three areas of action for sustainable food and agriculture: evidence, dialogue and tools. The tools required for the implementation of the climate-smart agriculture include analytical tools to create evidence and the tools mentioned in Figure C10.1 to guide policies and financing.

Figure C10.2. Theory of change for the implementation of the climate-smart agriculture at the national level

Problem	**Climate change is threatening agriculture's ability to feed a growing global population, provide the basis for economic growth and reduce poverty**
Needs	**Agriculture needs to transform to address this problem considering the objectives of climate-smart agriculture**

Problem	**Climate change is threatening agriculture's ability to feed a growing global population, provide the basis for economic growth and reduce poverty**		
	Evidence	**Dialogue**	**Tools**
Activities	Stocktaking of challenges and options	Identifying synergies and trade-offs in existing national development priorities	Screening of national planning mechanisms (see section 2.1, 'intervention options' for examples) and other relevant documents
	Identifying potential climate-smart agriculture interventions	Stakeholder consultations	Scenario-building exercises
	Expanding the evidence base for climate-smart agriculture objectives	Building evidence into planning	Downscaled climate and crop models
	Assessing barriers to adoption	Harmonizing policies and metrics	Economy-wide models
	Costing interventions	Creating inclusive platforms	Socio-economic models
	Prioritizing and planning: country-owned climate-smart agriculture strategies	Establishing and supporting dialogue with regional and international climate-smart agriculture platforms	Cost-benefit analyses
Practice change			
Outcomes	Capacities to identify, design, implement and monitor climate-smart agriculture interventions are enhanced		
Outcomes	Agricultural systems are climate-smart at all levels: plot, landscape, value chains and policies		
Outcomes	Continuous feedback loops have been established between science and policy on climate-smart agriculture		
Outcomes	The enabling environment is innovative, dynamic and capable of sustaining change		
Impact	**Agricultural productivity and incomes are sustainably improved in a resilient food and agriculture system that also harnesses mitigation opportunities, where possible.**		

Source: Authors

The implementation of climate-smart agriculture approach strives to achieve the three outcomes that are grouped under the fourth area of action 'practice change': the enhancement of capacities to identify, design, implement and monitor climate-smart agriculture interventions; the establishment of continuous feedback loops between science and policy on climate-smart agriculture; and the maintenance of an innovative and dynamic enabling environment capable of sustaining change. Ultimately, the desired impact of the theory of change is: "Agricultural productivity and incomes are sustainably improved in a resilient food and agriculture system that also harnesses mitigation opportunities where possible."

It is important to underline the fact that the four areas of action for sustainable food and agriculture are not linear. There are continuous interactions between these different areas, as highlighted in Figure C10.1. The steps described in the next section are organized under the headings of the 'evidence' column of the theory of change. They follow a logical flow to establish the needed evidence base to support climate-smart agriculture planning and implementation. At each step the necessary actions to establish dialogue and utilize available tools is considered. Given its overarching role in supporting the implementation of the climate-smart agriculture approach, capacity development and partnership building is addressed in a separate section. See also module C1 on system-wide capacity development.

Steps to undertake for implementing the climate-smart agriculture approach

C10 - 2.1. Stocktaking of climate challenges, intervention options and institutions to identify potential climates-smart agriculture interventions

Climate-smart agriculture interventions are site-specific, and all countries already have in place many policies and programmes that address the challenges of climate change. For this reason, the first step in implementing the climate-smart agriculture in a country involves a systematic documentation of: (i) existing challenges to food security within the context of the effects of climate change; (ii) the actions that are already in national plans with the potential to address these challenges by contributing to food security, climate change adaptation and/or mitigation; and (iii) the institutions that are involved in implementing these actions.

Climate challenges:

- Most of the evidence on the challenges posed by climate change on the agriculture sectors is based on global and regional assessments. Evidence at local and national levels remains scarce, but it is growing. To identify these challenges, a climate-smart agriculture approach needs to start with documenting existing evidence on downscaled impacts of climate change on crop and livestock production, forestry, and fisheries and aquaculture. The expected impacts of climate change, as manifested in changes in rainfall and temperature patterns, differ considerably from region to region, and this difference needs to be incorporated into climate-smart agriculture planning.
- For example, in Zambia, climate projections suggest that the dry areas in southern and central regions of the country will face a decreased availability of rainfall, and the northern regions, which already face high rainfall and suffer from leached soils, will become wetter (Kanyanga *et al.*, 2013). In the coastal areas of Viet Nam, the main challenge from climate change is saline intrusion, but in the country's highlands, the impacts are expected to be associated with landslides and frosts (World Bank 2010; MARD 2011). This diversity in expected impacts is likely to exist in most countries, and underlines the importance of systematic documentation of downscaled information to identify the vulnerabilities. This documentation would in turn enable the identification of potential climate-smart agriculture options that could be assessed as part of the national climate-smart agriculture strategy.
- Some of the widely used tools to conduct climate impact assessment are reviewed in detail in module C.8. The key element to highlight here is the importance of using multi-model ensembles rather than one model for making assessments, given the large uncertainties inherent in all models (Pierce *et al*., 2009).

Intervention options

- To identify potential options for climate-smart agriculture interventions that can be used to build a broader national climate-smart agriculture strategy, existing national agricultural development and investment plans, national climate change strategies, sustainable development plans, and/or key agriculture and climate change-related programmes need to be screened to create a list of policy priorities. Examples include: National Agriculture Investment Plans (NAIPs), National Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Programmes of Action (NAPAs), national communications to the United Nations Framework Convention on Climate Change (UNFCCC), programmes in developing countries to reduce emissions from deforestation and forest degradation (REDD+), and the Intended National Domestic Contributions (INDCs) submitted to the UNFCCC in advance of the Paris Agreement. These documents have already laid some of the groundwork for identifying potential climate-smart agriculture strategies and practices, which may figure on the list of possible climate smart agriculture options for assessment and evidence gathering.

- Module C.3 provides a detailed discussion on policies and programmes along with tools for screening them. Module C4 on investing in climate-smart agriculture also provides information on screening options (see also for example the methodology presented in the 2012 FAO publication, *Identifying opportunities for climate-smart agriculture investments in Africa*. It is important to highlight that, in all agricultural sectors, the entry points for implementing climate-smart agriculture will be at multiple levels (e.g. field, landscape, food system, institutional). The steps involved in screening for potential options need to cover all the necessary documents that address national development priorities at these levels.
- In most countries, this step will lead to a long list of locally suitable options that can contribute to one or more of climate-smart agriculture's objectives. However, the fact that a practice or strategy may contribute to reaching one climate-smart agriculture objective, does not make it climate-smart. Evidence needs to be gathered to document the contributions to all the three objectives: sustainable increases in agricultural productivity and incomes, climate change adaptation and, where relevant, mitigation. This initial list of options provides the basis on which the evidence needs to be expanded (as detailed in section C10.2.2) to document the contributions a particular option can make to all three climate-smart agriculture objectives, and indicate potential synergies and trade-offs among these different contributions.

Institutions

- Institutional mapping to identify the institutions at all levels that have a mandate to support climate smart agriculture objectives is a critical step in the implementation of climate-smart agriculture approach. Based on the options for climate-smart agriculture interventions identified during the screening process, this step then identifies the institutions that are responsible for delivering strategies and complements it with the inclusion of informal institutions (e.g. village committees, customary land tenure rules, farmer's organizations) and non-governmental organization or donor organizations that could have a role in implementing, facilitating and supporting climate-smart agriculture. The institutional mapping is also intended to gain a better understanding of the gaps that need to be filled and obstacles that need to be addressed to ensure a supportive enabling environment for climate-smart agriculture.

These stocktaking steps will provide a broad understanding of the challenges the climate-smart agriculture needs to address, the potential climate-smart agriculture intervention options that are already programmed in national policies, programmes and strategies, and the institutions that can support the design and implementation of the climate-smart agriculture approach. Based on the outputs of this step, the next step builds evidence on the contributions different options can make to reaching climate-smart agriculture objectives, including evidence of the trade-offs and synergies between these different options, the barriers to their adoption and their costs and benefits.

C10 - 2.2. Expanding the evidence base

One of the defining features of climate-smart agriculture is its heavy reliance on location-specific evidence on the benefits and costs of potential options, the barriers to their adoption, and the synergies and trade-offs that are involved. This evidence, however, is critical for prioritizing climate-smart agriculture options. This section considers different components required to build the evidence base with an emphasis to methods, data sources and tools.

i. Assessing the contributions interventions make to achieving climate-smart agriculture objectives

- This step is the most demanding. It involves gathering the scientific evidence needed to assess the contributions potential climate-smart agriculture interventions can make to improved agricultural productivity and incomes, adaptation and mitigation at a range of scales. Most climate-smart agriculture intervention options are part of existing strategies to achieve sustainable development and green growth, reach Sustainable Development Goals or realize national agricultural development plans (see module A1). Consequently, the burden of proof to identify the degree to which the interventions are climate-smart falls on the planners and scientists, who must ensure there is robust evidence for any proposed climate-smart agriculture intervention. Assessments of proposed interventions need to cover a wide range of spatial and temporal scales, and provide information on the contributions these interventions will make to reaching climate-smart agriculture objectives in a variety of agro-ecological and socio-economic settings under current conditions, as well as under different climate change scenarios.

- In this section, the contribution a potential intervention can make to each climate-smart agriculture objective is first reviewed separately before assessing the potential synergies and trade-offs among these contributions. The evidence required for barriers to adoption of climate-smart practices will also be considered, as it is critical for planning and targeting interventions.

Objective 1: Sustainable increases in productivity and incomes

The contributions of climate-smart agriculture interventions to increased productivity and incomes can be measured using various indicators (e.g. crop yields, agricultural income, total income, food consumption and food deficit). Most of these indicators can document the different dimensions of food security: availability, access, stability and utilization. (For details about the four dimensions of food security, consult the 2008 FAO publication, *An Introduction to the Basic Concepts of Food Security*). Indicators need to clearly identify which dimension of food security is improved by the practice or policy intervention. A large set of indicators are used to track food security outcomes. Most of these are at the household or production unit level (e.g. food consumption expenditure per capita, crop production per hectare, milk production per cow). Most indicators are also project-based (e.g. project participants have achieved 50 percent increase in maize production per hectare) and are used in project monitoring and evaluation (see module C9). Given the proliferation of indices to track food security outcomes, the choice depends on the availability of data at the relevant levels and national food security targets.

Methodologies to determine the contributions of interventions to the first objective of climate-smart agriculture include household-level socio-economic studies, economy-wide models, scientific trials or biophysical and structural models. Carefully designed scientific trials on experimental plots or in laboratories provide valuable information on the potential food security outcomes of field- and farm-level practices (e.g. cereal-legume intercropping, improved feed management for livestock). However, to assess the potential impact of these practices on agricultural productivity and incomes at the national level, they should be ideally combined with larger-scale socio-economic analyses, which can incorporate current and potential management conditions.

More and more nationally representative household surveys with detailed agricultural modules are becoming available. Examples include the World Bank's Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA, National Crop-Forecast and Post-Harvest Surveys and the Agricultural Census. High-resolution data on climate variables are increasingly integrated into socio-economic studies in order to assess a large set of field- and farm-level practices controlling for critical weather variables and agro-climatic shocks (Di Falco *et al*., 2011; Arslan *et al.*, 2015; FAO, 2016, Asfaw *et al*., 2016; Asfaw, Di Battista and Lipper, 2016). It is important to ensure that there is enough cross-sectional diversity in the data used in these studies to cover areas with different exposure and vulnerability to risks and adaptive capacities.

Module C.9 looks at various approaches for impact evaluation as part of monitoring and evaluation processes for climate-smart agriculture projects. One of the critical difficulties in this area is the attribution of impacts to a specific intervention. The question that needs to be answered clearly for attribution is: are the documented benefits solely due to the use of the practice or strategy, or are there other confounding factors, unrelated to the intervention, that have affected the outcomes? A large set of variables needs to be controlled for to be able to answer this question. Close collaboration with local agricultural research institutions is required to identify the variables that affect productivity and shape farmers' decisions. These variables depend on the particular structures of the agricultural production systems in each country. For example, the onset date of the main rainy season and farmers' access to weather information are very important determinants that needs to be controlled for in Malawi and Zambia. On the other hand, in the northern mountainous region of Viet Nam, the incidence of extreme rainfall events is a much more important determining factor for productivity and incomes. Among other important variables are the existence, mandates and capacities of institutions. This information can be identified based on the institutional mapping step (described above) in collaboration with national experts. The existence of input subsidies, land tenure arrangements and the availability and access to extension information, including weather information, are examples of variables that need to be controlled for to ensure that findings are attributable to the climate-smart agriculture practice or strategy being analysed.

The costs, both in terms of money and time, of setting up proper quantitative impact assessment studies may be prohibitive in many cases. A more feasible socio-economic analysis tool would be the use of panel data methodologies (i.e. the same households are observed over multiple years) to control for variables that affect agricultural productivity and incomes (Wooldridge, 2002). Many households choose to adopt certain practices and strategies based on characteristics that are both observable (e.g. age, education, wealth) and unobservable (e.g. ability). For these reasons, the observed outcomes cannot be directly linked to the adoption of a practice if these other factors are not controlled for. This confounding factor can be removed using panel data methodologies or instrumental variable approaches for clearer attribution (Arslan *et al*., 2015; Asfaw, Coromaldi and Lipper, 2015; FAO, 2016a). In the absence of panel data, careful quasi-experimental methodologies using large-scale household data can also be used to assess the impact of one practice on outcomes associated with productivity and income (Kassie *et al*. 2010). However, establishing attribution is harder in these analyses.

Socio-economic studies that are based on econometric analysis of household data are also able to assess how interactions between practices and climate variables affect outcomes. These studies can also be used to analyse livelihood strategies, as well as field- and farm-level practices that contribute to food security. They can provide valuable information on the role of institutions (e.g. social safety nets, input subsidies, weather information services) and a large set of other socio-economic variables, including gender, that contribute to shaping outcomes (Arslan *et al.*, 2015; FAO, 2015; FAO, 2016b). Once the analyses have been conducted and the effects of relevant shocks have been controlled for, the results can be combined with localized climate change projections to simulate how the contributions the analysed options make to increased productivity and incomes may be expected to change in the future. This exercise also can provide information about the sustainability of the documented benefits and the risks associated with the practices under various scenarios.

Socio-economic studies based on econometric analysis of household data can only assess practices and strategies that have already been implemented and can be identified in existing data sources. Assessing the food security contributions of new innovative practices and strategies would require simulation models using economy-wide (general or partial equilibrium) models. Examples of these simulation models include:

- Asia-Pacific Integrated Model (AIM);
- Environmental Impact and Sustainability Applied General Equilibrium model (ENVISAGE);
- Future Agricultural Resources Model (FARM);
- Global Change Assessment Model (GCAM);
- Global Biosphere Optimization Model (GLOBIOM);
- Global Trade and Environment Model (GTEM);
- International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT);
- Modular Applied General Equilibrium Tool (MAGNET); and
- Model of Agricultural Production and its Impact on the Environment (MAgPIE).

For a comparison of global climate change modelling results, consult Nelson *et al*. (2014a, 2014b). Micro-simulations can also be used to analyse the effect of an intervention on production, incomes or other welfare outcomes at more aggregate levels.

The global simulation models listed above commonly use biophysical cropping system models. Examples of these cropping system models include:

- Agricultural Production Systems sIMulator (APSIM) (Keating *et al.*, 2003)
- Environmental Policy Integrated Climate (EPIC) model (Williams, 1990)
- Decision Support System for Agrotechnology Transfer (DSSAT) (Jones *et al.* (2003)
- Lund-Potsdam-Jena managed Land (LPJmL) model (Bondeau *et al.*, 2007)
- Nutrient Use in Animal and Cropping systems – Efficiencies and Scales FARM SIMulator (NUANCES–FARMSIM) (van Wijk *et al*., 2009).

These models, which simulate future crop and livestock productivity under various climate and socio-economic scenarios, can also simulate the impact of new practices on crop growth or livestock productivity. More recently, structural approaches that bring together economic and biophysical models are being used to provide a more detailed understanding of the combined effects of climate stresses and future socio-economic trends, such as price changes on trade balances, and input re-allocations in production (Nelson *et al*., 2014a; Fernandez and Blanco, 2015). These models can also be used to analyse the food security implications of technologies used in climate-smart agriculture (Islam *et al*., 2016).

In addition to the micro- and macro- level analyses required to build evidence for the contributions of different intervention options to the first objective of climate-smart agriculture, complementary meso-level analyses are needed to understand the impacts of the interventions in the food system. These can include the improvements in value chains, infrastructure and access to credit, insurance and information (see module B10 on climate-smart food systems)

Objective 2: Adaptation and resilience

The contributions made to food security by climate-smart agriculture interventions need to be assessed over time to establish their sustainability under multiple climate change scenarios. This is clearly connected to the adaptation objective of climate-smart agriculture: if the benefits identified are sustainable under the expected range of climate conditions, then they can also be said to contribute to adaptation. The range of climate-smart agriculture options can also be expanded by using additional analyses to identify the options that maximize food security benefits under expected scenarios. Creating evidence to show that an intervention has adaptation benefits calls for clear indicators of adaptation. This inherently complex issue is addressed in module A.2. For each intervention, it first must be determined the level at which the adaptation benefits will be analysed (field, household, landscape, regional, national). Then a set of suitable indicators must be selected that can show whether and how the proposed intervention improves the capacity of the system to deal with change.

The methodologies presented for measuring the food security outcomes of climate-smart agriculture interventions also have the potential to create evidence for adaptation. However, special attention needs to be paid to avoid assuming, without proper evidence, that a given intervention that is simply part of a business-as-usual agricultural development project also has adaptation benefits. There are many overlaps between agricultural development and climate change adaptation priorities. For this reason, evidence is needed to clearly situate any intervention along the continuum of development and adaptation (WRI, 2007).

For example, evidence that the use of certain modern inputs improves crop or livestock productivity would be considered a viable development priority, but it cannot be framed as adaptation unless evidence is established that these benefits persist under the expected impacts of climate change (Arslan *et al*., 2015; FAO 2016a). Evidence on how adoption affects exposure to the risks that are expected to become more frequent and severe is also useful in assessing adaptation benefits (Kassie *et al*., 2015). Livelihood diversification is a general risk-mitigation strategy, but to frame this activity as climate change adaptation, evidence needs to be provided to show that it also works under the specific risks brought by climate change in each locality (FAO 2015; FAO 2016b). Similarly, investments in social safety nets are valuable development interventions, but they need to be designed to make sure they can decrease vulnerability to climate shocks, as well as other types of shocks, to be part of an adaptation strategy. At the other end of the spectrum, some adaptation measures may more explicitly address climate change risks compared with traditional development interventions, such as the incorporation of climate information in decision-making or improving national capacities to respond to disaster risk (see module C5 on disaster risk reduction).

Objective 3: Mitigation

One of the main concerns that led to the development of the concept of climate-smart agriculture was the fact that the agriculture sectors were being left out of international discussion on how to address climate change and that funding for mitigating climate change was being concentrated almost exclusively on other sectors (see also module A1). Recognizing the role of agriculture in mitigation and harnessing the synergies between mitigation, adaptation and food security was one of the first premises of climate-smart agriculture. This initial emphasis on mitigation in climate-smart agriculture generated some heated debate. Since then, there has been an increased emphasis on the contributions climate-smart agriculture can make to food security and adaptation (Lipper and Zilberman, 2017). Nevertheless, in the Paris Agreement, the vast majority of developing countries have included the agriculture sectors in their mitigation commitments. Mitigation remains an important objective of climate-smart agriculture and evidence is needed to demonstrate the mitigation benefits of climate-smart agriculture interventions.

The contributions of potential climate-smart agriculture practices and strategies to reducing greenhouse gas emissions and increasing carbon sequestration in agriculture need to be documented to establish the evidence on the degree to which specific agricultural interventions can be considered climate-smart and make the case for scaling them up in a broader climate-smart agriculture strategy.

Methodologies that estimate greenhouse gas emissions are commonly differentiated into three tiers (IPCC, 2006). Tier 1 methods consist of the use of default equations and parameter values that are provided in global reference methodologies and databases differentiated by rough agro-ecological zones. In combination with data on the type and scale of agricultural practice and technology use, Tier 1 methodologies facilitate the estimation of greenhouse emissions without the requirement of complex input data. Examples of greenhouse calculator tools that provide a guided interface to applying Tier 1 methodologies include:

- The Ex-Ante Carbon-balance Tool (EX-ACT) (Bernoux *et al.*, 2010; Bockel *et al.*, 2013; Grewer *et al.*, 2013)
- The Carbon Benefits Project Tool (Milne *et al.*, 2010)
- The AFOLU Carbon Calculator (Winrock International, 2013);
- The Cool Farm Tool (Hillier *et al.*, 2011).

Tier 2 approaches can use the same methodologies as Tier 1 approaches, but make use of country- or region-specific data. Tier 2 approaches also utilize higher temporal and spatial resolutions and more disaggregated activity data. Examples of Tier 2 methodologies include the Global Livestock Environmental Assessment Model (GLEAM) (FAO, 2016c) and the statistical approach to nitrous oxide and nitric oxide emissions developed by Stehfest and Bouwman (2006).

Tier 3 approaches use higher order methods, such as dynamic biogeochemical models and/or greenhouse gas field measurement techniques. If applied correctly, Tier 3 methodologies provide greenhouse gas estimates that are the most specific to the given production system, location, and timeframe of analysis. Examples of Tier 3 methodologies include:

- DayCent (Del Grosso *et al.*, 2002);
- DNDC (Li *et al.*, 1992);
- Roth C (Coleman and Jenkinson, 1996); and
- The Modeling Organic Transformations by Microorganisms of Soils (MOMOS) (Pansu *et al.*, 2009).

The application of Tier 3 methodologies requires the availability of detailed disaggregated data on a variety of factors (e.g. soils, weather and agricultural activities). While there are efforts to make tier 3 methodologies more user-friendly (e.g. COMET-Farm tool), the majority of greenhouse gas estimations used for policy planning and national reporting rely on Tier 1 methodologies.

In economies highly dependent on subsistence agriculture for food security, climate change mitigation in agriculture may not be a high priority. However, in some production systems, climate change mitigation may be one of the strongest objectives of the climate-smart agriculture intervention. Examples of potential climate-smart agriculture interventions with significant expected mitigation benefits include improved livestock breeding and management; improved pasture management and restoration; improved paddy rice management; and decreasing deforestation and forest degradation that is being driven by agricultural area expansion and climate change.

Synergies and trade-offs

Based on the evidence gathered on the contribution an intervention can make to each objective of climate-smart agriculture, the synergies and trade-offs among these different contributions can be identified. Interventions with significant synergies would then be prioritized to maximize the returns on investment to meet national agricultural development and climate change goals. In case of trade-offs, (e.g. improving productivity and its stability while causing increased deforestation), complementary policies need to be built into climate-smart agriculture strategies to manage these trade-offs in ways that are in line with overall country development priorities.

The Climate-Smart Agriculture Compendium provides resources to carry out a systematic analysis of the synergies and trade-offs among climate-smart agriculture objectives for a large set of field-level practices. (see Box C10.1).

Box C10.1 The Climate-Smart Agriculture Compendium: A science-based decision support tool for field level climate-smart agriculture practices

Climate-smart agriculture has gained a high profile in the international discourse on sustainable agriculture and climate change. Climate-smart agriculture initiatives have multiple objectives and are highly context-specific. However, the scientific evidence to evaluate the contribution climate-smart agriculture practices make to reaching these objectives, as well as the synergies and trade-offs involved in making these different contributions is scant. This lack of evidence complicates efforts to translate climate-smart agriculture from a concept into concrete actions. To address this need for field-level practices, which are one of the key entry points for making the transition to climate-smart agriculture, the World Agroforestry Centre (ICRAF) partnered with CCAFS, FAO, and the International Center for Tropical Agriculture (CIAT) to conduct a meta-analysis of all published scientific literature to date on potential climate-smart agriculture practices in Africa.

The resulting Climate-Smart Agriculture Compendium aims to evaluate current knowledge on the effectiveness of more than 70 field-level management practices extracted from more than 1,500 published papers on productivity, resilience and climate change mitigation in African farming systems. The Compendium also allows for an assessment of synergies and trade-offs among the three objectives using meta-analysis methodologies that can enable a prioritization of different policy initiatives. Currently, a web-based platform is being developed to make the Climate-Smart Agriculture Compendium available to policy makers as decision tool, which will allow searches and simple analyses of climate-smart agriculture objectives under specific soil types, agro-ecological zones, and categories of practices (e.g. agronomy, agroforestry, livestock, post-harvest systems and energy systems). Scientists will also be able to use the compendium to identify and fill research gaps. It is the most comprehensive review of scientific evidence to date that feeds into current and future climate-smart agriculture prioritization tools, which incorporate evidence base with conceptual approaches to support national prioritization efforts among multiple objectives.

Many agricultural practices are being labelled as 'climate-smart' without due diligence being given to the importance of location-specific scientific evidence. This can create confusion, as many of these practices are likely to be climate-smart in certain places, but none of them are likely to be climate-smart everywhere. An additional challenge comes from the timescale. Under the dynamic effects of climate change, practices that may be climate-smart today might not be by 2030. The scale at which interventions are implemented also matters. Policies need to take these dimensions into account before promoting interventions for food security and resilience. Given that climate-smart agriculture is an approach to policy making, rather than a fixed set of practices, the Climate-Smart Agriculture Compendium will shed light on areas of uncertainty and confusion in order to support sound policies that can create resilient food systems in Africa.

Source: Rosenstock *et al*. (2015) – as published in AASR 2016.

In addition to the trade-offs and synergies among the three objectives of climate-smart agriculture at the field level, climate-smart agriculture interventions also needs to account for synergies and trade-offs at different levels. For example, an intervention that delivers synergies at the field level to all households, may involve making trade-offs at the landscape or village level (Andrieu *et al*., 2015; Baudron *et al*., 2015). Klapwijk *et al*. (2014) have provided a summary of a number of methods for analysing these trade-offs. Participatory, empirical and experimental methods as well as simulation and optimization methods, can be used in different combinations to support an examination of system-level interactions.

ii. Analysis of the drivers and barriers to adoption

The implementation of climate-smart agriculture interventions at the field level or at the farm, livelihood or landscape level, ultimately depends on households and/or groups of households adopting the proposed climate-smart agriculture practices. The adoption of agricultural technologies is a complex process. It depends on many variables including the attitudes towards risk; affluence and other socio-economic characteristics of the decision-makers; agro-ecological conditions; and the functioning of markets and institutions (Feder *et al*., 1985). Even if a climate-smart agriculture practice is shown to deliver significant benefits in terms of agricultural productivity and adaptation, the interactions between these different variables may prevent the adoption and scaling up of practices. A climate-smart agriculture strategy needs to include an analysis of these barriers, which is based on a systematic review of local institutions and their impacts on the choices households make regarding agricultural production.

Qualitative methods (e.g. local-level dialogues, focus group discussions, expert consultations) can provide a good starting point for understanding the local drivers and barriers to adoption. These should ideally be complemented with quantitative methods based on socio-economic analyses of adoption patterns that use large-scale data from the households that are expected to benefit from the adoption the of the practice or strategy. The traditional ways of analysing barriers to adoption (e.g. small-scale, project-based) need to be updated to pay special attention to controlling for climate change shocks and policies and institutions that affect incentives for adoption. Specific consideration must be given to institutions associated with risk management (e.g. insurance schemes, credit services, safety nets). By changing the risk profiles of the range of livelihood options available for agricultural households, climate change is increasing the importance of these institutions.

Findings from recent studies, which have benefited from the availability of high-resolution climate and soil data, and large-scale agricultural household data, indicate that high levels of long-term variability in rainfall and temperatures, and a rainfall shortfall during relevant cropping seasons significantly affect the adoption of agricultural technologies. In most cases, these climate shocks increase the incentives to adopt improved agricultural practices that have the potential to be climate-smart (e.g. soil and water conservation, the incorporation of residues into fields, and legume intercropping). These climate shocks decrease incentives to adopt inorganic fertilizers whose benefits largely depend on predictable rainfall at critical periods (Arslan *et al*., 2014a; Asfaw *et al*., 2016; Arslan, Belotti and Lipper, 2016).

In a wide variety of settings, access to locally relevant extension information is one of the most important determinants for the adoption of climate-smart agriculture practices. This finding highlights the importance of upgrading extension systems to incorporate the local impacts of climate change as part of climate-smart agriculture strategies. Evidence on the determinants of the adoption of other potential climate-smart agriculture strategies, such as livelihood diversification or crop insurance, is also needed to identify the market and institutional constraints that need to be addressed for the effective planning and targeting of climate-smart agriculture interventions.

iii. Costing interventions

The costs of the climate-smart agriculture options also need to be documented to assist in the prioritization of the potential options. The results of this process will complement the data collected on the benefits that have been analysed and documented in the preceding steps. The analysis of barriers to adoption can identify some costs as barriers (e.g. high labour, input or transportation costs). However, more detailed analyses are needed to precisely identify the costs and benefits at each point in the production activity or value chain in question. Specifically designed cost-benefit analyses at the field, farm or household level can be employed to do this (Branca *et al*., forthcoming; Branca, forthcoming). It is also important to pay attention to opportunity costs, which are often overlooked in these analyses. Some examples of opportunity costs include the foregone value of household's time that could have been used for another income generating activity, or the foregone value of crop residues left on the field that could have been fed to animals. To ensure the results are representative, household, landscape and value chain analyses may require data collection that specifically covers all the relevant costs of the options considered under various farming systems, and under a range of socio-economic and agro-ecological conditions. Simple cost-benefit analyses provide an overall understanding of how costs and benefits compare on average under different systems. Attention also needs to be paid to not confuse the results of cost-benefit analyses for the system, socio-economic and agro-ecological condition at hand, with causal interpretation. Ideally these types of analyses should be combined with econometric analyses to control for a large set of variables that shape decisions and outcomes to validate the results of average cost-benefit analyses (Branca *et al*., 2017).

At the national level, it also becomes important to analyse the costs of inaction by assessing the damage that can be avoided in the future. These types of studies have inevitably very large scopes. They start by estimating the costs of the impacts of climate change on the natural and economic system as a whole under various scenarios, and then estimating the costs of the various policies needed to adapt to climate change. The State of Food and Agriculture (SOFA) 2016 (FAO, 2016d) provides examples of the evidence that has been obtained so far on the costs of adaptation and the costs of inaction. Currently, the findings are primarily at the global scale, but there is an increasingly number of national studies available (see FAO 2016d, Chapter 3). For example, a recent study from Uganda reports that interventions, such as improving water-use efficiency in irrigation systems, improving crop and livestock varieties, and improving access to credit would cost a total of USD 300 million by 2030. On the other hand, the costs of inaction, in terms of reduced crop and livestock production, and reduced exports, range between USD 22 billion and USD 38 billion – a very high benefit-cost ratio for these interventions (Markanday *et al*., 2015).

These analyses facilitate the evaluation of different interventions under various scenarios and enable the prioritization of investments within a strategic framework for climate-smart agriculture.

C10 - 2.3. Prioritizing and planning for country-owned strategic frameworks for climate-smart agriculture

The evidence gained from the preceding steps needs to be combined and programmed into a country-owned strategic framework for climate-smart agriculture. These strategic frameworks are intended to be national in scope but emphasize the local contexts of proposed interventions and the potential international links. Climate-smart agriculture is important in the international discourse on policies and in international funding mechanisms for addressing climate change and agriculture. For example, funding explicitly targeted for climate change in agriculture can come from sources such as, the Global Environment Facility (GEF) or the Green Climate Fund (GCF). Overseas development assistance can provide a more implicit source of funding. Having a strategic framework in place would enable countries to be ready to take advantage of the opportunities for funding, planning and implementation as they arise. The strategic framework needs to systematically use the evidence that has been generated to prioritize climate-smart agriculture interventions and at the same time make sure that they contribute to national development goals and climate change strategies. As discussed earlier, most countries have multiple policies, programmes and strategies that may address part of the CSA objectives. Integrating CSA into these existing documents may seem like a sufficient way of moving towards CSA at the national level. Given the need to address multiple objectives at multiple geographic and time scales, however, a unifying CSA strategic framework is needed to identify the synergies and tradeoffs that exist between already existing policies, programmes and strategies. This would also help with the prioritisation of proven CSA interventions to facilitate access to funding.

The prioritization of climate-smart agriculture interventions necessarily entails ranking and weighing different options based on their benefits, costs and risks. This is a process that should involve all stakeholders. There are a number of prioritization tools for climate-smart agriculture that have been prepared by different organisations, including the previously mentioned Climate-Smart Agriculture 101, particularly the section on [Targeting and prioritization]; the [Climate-smart Agriculture Profiles], which were developed by CIAT, the Tropical Agricultural Research and Higher Education Center (CATIE) and CCAFS, with support by the World Bank; and the Climate-Smart Agriculture Compendium (see Box C10.1).

These tools emphasize the importance of stakeholder participation and dialogue, and provide quick approaches for ranking different practices. Most of the practices in these toolkits, however, are at the field level. National level prioritization exercises for climate-smart agriculture strategic framework should also include other interventions, such as improvements in national agro-meteorological information systems, disaster risk management, value chains and the food system, and in the institutions supporting climate-smart agriculture, including safety nets, credit services and insurance schemes. Given the broader set of options that have to be considered at the national level, the stakeholder consultations need to be designed accordingly to ensure the participation of all relevant groups.

At the national level, the prioritization process may give different results when the benefits and costs of implementing climate-smart agriculture policies in all sectors are aggregated. It is important to emphasize that 'triple-win' interventions – interventions that simultaneously increase productivity and incomes, build the capacities of vulnerable communities to adapt to the impacts of climate change, and reduce or remove greenhouse gas emissions – will likely be the exception rather than the rule at lower levels of interventions. When costs and benefits are aggregated, a national climate-smart agriculture strategy is likely to yield different priorities than those found at local levels. The process for prioritization should primarily try to achieve the national goals for agricultural development and climate change adaptation and mitigation, and weigh different options against other interventions that could have been implemented with limited funds (e.g. increasing fertilizer subsidies versus investing in climate information and early warning systems). The prioritization should use the evidence base to maximize the synergies and minimize the trade-offs among the identified options. Given the dynamic nature of the objectives of climate-smart agriculture, assessments should look at whether these options, as well as their potential synergies and trade-offs, are pertinent not just for today's conditions, but also under the expected impacts of climate change.

A climate-smart agriculture strategy should be considered a living document. It will need to be updated as new information and tools become available. Ideally a nation-wide climate-smart agriculture coordination group with representatives from a range of government ministries, research organizations, private sector organizations and producer groups would be established for this purpose. The FAO Economics and Policy Innovations for Climate-Smart Agriculture (EPIC) programme has done this in their partner countries in Malawi, Viet Nam and Zambia to ensure continuity in national climate-smart agriculture activities (Arslan *et al*., 2014b). For more details see the Box C3.2 in module C3. These coordination groups can ensure that the national climate-smart agriculture strategy is kept up to date and strategically used to access financing.

Financing options and mechanisms

The transition to climate-smart agriculture relies on the capacity to think strategically and formulate policies and programmes to access financing for the implementation of a national climate-smart agriculture strategy. Capacity-building activities may be needed to take advantage of the range of possible funding sources. The growing number of financing options for climate-smart agriculture have been considered in detail in module C4. To ensure continuity in the implementation of the climate-smart agriculture strategy, it is also important to mainstream climate-smart agriculture activities into national budgets and other national sustainable development programmes and projects.

Capacity development and partnership building

As illustrated in the theory of change presented in Figure C10.1, the activities listed in the preceding steps all aim to achieve the outcomes that underpin the practice change component of the FAO approach to sustainable food and agriculture. Capacity development and partnership building is one of the key threads that runs through all of these activities. System-wide capacity development is addressed in detail in module C.1. This section highlights some of the key capacities that need to be enhanced to sustain practice change and integrate climate-smart agriculture into policies that extend beyond specific projects and programmes.

i. Capacity development in information management

Given the dynamic nature of the challenges posed by climate change to all agricultural sectors, countries need to strengthen their capacities to continuously update the information available on climate change and identify options to decrease vulnerabilities. Because the technology for data collection, (both on climate and production), modelling and dissemination is improving at a rapid pace, a dynamic approach must be taken to capacity development. It is no longer a lack of data, but a lack of capacities to process data that creates bottlenecks in carrying out timely downscaled analyses for identifying the most pressing risks and vulnerabilities associated with climate change and recommending actionable responses. Countries need to invest in capacity development in this area and integrate capacity-development activities into their regular agricultural development planning to maintain the practice change needed for climate-smart agriculture. This includes strengthening capacities at national meteorological institutions, universities and research institutions.

One area where capacity development is required is in the use of weather station information to assess current and future climate impacts and vulnerabilities in the agricultural sectors. The FAO integrated interdisciplinary tool, Modelling System for Agricultural Impacts of Climate Change (MOSAICC), puts a strong focus on capacity development (see Box C10.2).

Box C10.2 Modelling System for Agricultural Impacts of Climate Change (MOSAICC)

There is a need to strengthen the evidence base about current and future climate impacts and vulnerabilities in the agriculture sectors at different spatial and temporal scales. A broader evidence base is a crucial component in efforts to support climate-smart agriculture projects and programmes. The existing scientific information does not always match the needs of policies or projects in terms of scale and focus. Due to insufficient technical capacities in many countries, analyses in this area are often conducted by international experts rather than local researchers. In many cases, these analyses are carried out with only minimal engagement of local stakeholders (e.g. national research institutes and universities). To fill these information and capacity gaps, FAO developed an integrated interdisciplinary tool, Modelling System for Agricultural Impacts of Climate Change (MOSAICC), which has been applied in several countries.

FAO emphasizes a country-driven process for implementing MOSAICC. The creation of an interdisciplinary technical working group is one of the first steps in this process. This working group is typically composed of representatives from government ministries, national research institutes and universities. Its main members group are experts who are responsible for running simulations using each of MOSAICC's components. The group also includes policy makers as the primary the stakeholders. As members of the working group, the policy makers help guide the climate change study from study design to the communication of the results. Other government technical offices can provide necessary data and expertise. This institutional framework ensures that the information produced by the technical working group using MOSAICC is a useful output for stakeholders rather than a purely academic exercise. The users of MOSAICC can perform the simulations at different time scales and spatial scales (e.g. subregional to national level) based on the needs and interests of stakeholders.

Capacity development is an important focus of the MOSAICC implementation strategy. Climate change adaptation planning is a long and iterative process that should be periodically reviewed as new scientific evidence and the outcomes from adaptation interventions become available. The enhanced capacities of national experts to carry out scientific work that broadens evidence base about the impacts of climate change and adaptation are vital to a sustainable policy planning process. FAO provides extensive training programmes to local experts on the use of each component of MOSAICC. At least one week of training per component is usually provided. In each country, FAO has facilitated collaboration among different ministries and institutions to make interdisciplinary studies possible. In successful collaborations, the software design of MOSAICC becomes catalytic. The sustainability of strengthened technical capacities of individual experts is ensured by the commitment of all stakeholders represented in the interdisciplinary technical working group. The trainers, who are the original developers of MOSAICC models, continue to provide technical support to make sure the experts can accomplish simulation studies even after the training. In the end, country experts become proficient enough to design the study, perform simulations using their country's own data, and publish the results to inform policy stakeholders to support national planning.

Source: Authors

ii. Capacity development in research

Building the evidence base required for scaling up climate-smart agriculture is a very demanding ongoing process. A large set of stakeholders across multiple disciplines (e.g. agro-meteorology, biophysical sciences, agronomy, economics, social sciences, political science) need to have the capacities to sustain this process. Each step of the process requires strong partnerships to make sure that a scientifically sound climate-smart agriculture approach is continuously applied through established feedback loops between science and policy.

Building strong monitoring and evaluation components into climate-smart agriculture projects are addressed in module C.10. Countries also need to invest in regular impact evaluations of the most important national policies that have the potential to contribute to climate-smart agriculture objectives. Continuous updating of the evidence base would ensure that changing vulnerabilities are identified and addressed on time. One way to achieve this would be strengthening the capacities of the central statistical offices, which would improve the data in nationally representative surveys for agricultural sectors (e.g. agricultural census, living standards measurement survey, national census). These surveys should be updated to include modules that can provide a better understanding of climate change adaptation and mitigation implications of the data and, where required, expanded to include the whole food system (McCarthy, 2011). Investing in initiatives to create strong monitoring and evaluation components in the private sector and farmers' organizations, and connecting them to national information centres for use and dissemination are also activities that will support capacity development.

National capacities to analyse this type of data can be enhanced by including courses on climate change and agriculture into the curricula of higher education institutions. Building partnerships with international organizations engaged in scientific and policy research is also critical. A good example of this was the approach taken by FAO-EPIC in Malawi, Viet Nam and Zambia. Between 2012 and 2015, this project supported Masters and PhD students from different disciplines in their research on local climate-smart agriculture options. In some cases, students participated in international exchange programmes to improve their technical backgrounds. All of the alumni of this project have remained in their countries where they continue to work (mostly in ministries of agriculture) on issues related to climate change and agriculture and contribute to the implementation of climate-smart agriculture.

iii. Capacity development in stakeholder processes

To make sure that the strategic climate-smart agriculture frameworks are living documents and kept up to date as new scientific evidence and international policy directions become available, the multi-stakeholder climate-smart agriculture core groups that are established in each country need to make sure that their members are continuously engaged in national, regional and international dialogues. Examples of opportunities for participating in international discussions include UNFCCC negotiations; discussion forums on Sustainable Development Goal indicators and monitoring; meetings organized by the Intergovernmental Panel on Climate Change (IPCC) to disseminate their findings; events organized by regional partnerships on climate-smart agriculture commitments, such as the New Partnership for Africa's Development (NEPAD) Vision 25x25 initiative; and meetings of global, regional and national climate-smart agriculture alliance networks. Organizing periodic national meetings to disseminate the results of these discussions to national and subnational policy makers, research organizations, farmers groups and private sector representatives would also ensure that climate-smart agriculture has broad long-term support in the country.

iv. Capacity development in evidence-based decision-making

Having national capacities in place for evidence-based decision-making is one of the key elements for supporting climate-smart agriculture. In the theory of change developed in this module, these capacities are essential for creating the necessary continuous feedback loops between science and policy. The main funding sources for climate-smart agriculture (e.g. GCF, GEF) require rigorous monitoring and evaluation systems, and robust evidence that can demonstrate that investments are delivering what they promise. For this reason, the processes to prepare proposals and implement these projects can be a catalyst for this type of culture change. A mechanism should be established that allows for coordination among national focal institutions responsible for preparing climate-smart agriculture proposals for funding, so that they have the opportunities to share evidence and expertise that can help in the preparation and delivery of outputs. This will also contribute to developing capacities for evidence-based decision-making over the long-term.

Conclusions

Climate-smart agriculture is a broad approach with ambitious goals, which involve a broad diversity of range of sectors, stakeholders and disciplines, and cover a range of geographic locations and timescales. Consequently, the transition to a climate-smart agriculture requires changes at many levels of policy making. To facilitate these changes, this chapter has developed a theory of change for climate-smart agriculture that provides guidance for the evidence-based implementation of a national approach climate-smart agriculture. The theory of change lays out an overarching set of steps that are recommended for facilitating the integration of climate-smart agriculture into national policy making. The successful implementation of climate-smart agriculture interventions relies heavily on location-specific evidence. This module has noted a number of tools and methodologies that can be used to enhance the evidence base and build a solid climate-smart agriculture strategic framework. Capacity development and partnership building also plays a central role in a sustaining and updating this framework over time.

The implementation of activities, which are based on robust evidence and contribute to climate-smart agriculture, can be undertaken at the local, national or regional levels. However, it is critical to recognize that 'triple-win' climate-smart agriculture interventions will likely be the exception rather than the rule, especially at lower levels of interventions. A holistic national climate-smart agriculture strategy must encompass all these levels and extend over a long-term time horizon. The priorities of this strategy need to be in line with broader national sustainable development goals to ensure the systemic transformation of agricultural systems in the face of climate change.

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Acronyms

CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CIAT	International Center for Tropical Agriculture
GCF	Green Climate Fund
GEF	Globally Environment Facility
UNFCCC	United Nations Framework Convention on Climate Change

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