A2 Climate change adaptation and mitigation

Overview

Agriculture, climate change and poverty are strongly interlinked. Agriculture is a major source of greenhouse gas emissions both directly through productive activities and indirectly through changes in land use. In turn the impacts of climate change are already felt in agriculture (see module A1), with specific impacts in each agricultural sector (crop production, livestock production, forestry, and fisheries and aquaculture as discussed in chapters B1 - 1.1, B2 - 1.1, B3 - 3.3, and B4 - 3.1 respectively), especially on poor populations whose livelihoods and food security are highly dependent on the climatic conditions.

Central to globally coordinated efforts to address climate change is the Paris Agreement, adopted in December 2015 under the United Nations Framework Convention on Climate Change (UNFCCC). It sets out three objectives, commonly referred to as the Paris Agreement's mitigation, adaptation and finance goals

a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and

c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

As the demand for food and agriculture related products is expected to increase, the Paris Agreement's mitigation goal can only be achieved if emissions from agriculture are significantly reduced alongside emissions from other economic sectors. However, while countries work towards minimizing global surface temperature increase by collectively reducing greenhouse gas emissions, the climate continues to change. Due to inertia inherent in the climate system, temperatures would continue to rise to some extent even if emissions were eliminated in the present. This is why, regardless of any ongoing mitigation efforts, it is essential to transform the agricultural sectors in such a way that it simultaneously reduces emissions, increases production and foster adaptation and resilience to climate change, in line with the Paris Agreement's preamble that recognizes the fundamental priority of safeguarding food security and ending hunger.

Making decisions about which climate change adaptation measures may be necessary involves an understanding of what impacts climate change is likely to bring about, identifying the risks and opportunities associated with these impacts, and taking steps to address them. Specific guidance on the assessment of climate change impacts and vulnerability and appraisal of climate-smart agriculture options are discussed in module C8. Climate-smart agriculture programme monitoring and evaluation is addressed in module C9.

This module introduces the place of adaptation and mitigation in the UNFCCC process and the Intended Nationally Determined Contributions (INDCs) submitted by countries (chapter A2 – 1), and presents the major types of climate change impacts assessments (chapter A2 – 2). This module then provides an overview of the key concepts and approaches pertaining to both adaptation (chapter A2 – 3) and mitigation (chapter A2 – 4), including developments on the adaptation gaps and needs, as well as on the mitigation potential and cost.

Key messages

- Both adaptation and mitigation implications must be taken into account when designing and implementing climate-smart agriculture. Depending on the context, interventions to implement climate-smart agriculture may focus more on either adaptation or mitigation, in line with the specific needs and objectives to be met.
- Opportunities must be sought to maximise synergies and co-benefits between adaptation and mitigation. Often climate-smart agriculture can simultaneously result in adaptation, mitigation and/or productivity gains.
- Based on countries' Nationally Determined Contributions to the Paris Agreement, the agriculture sectors are the foremost priority for adaptation. Countries highlight the vulnerability of the agriculture sectors to climate change, and reflect on the importance of disaster risk management in the agriculture sectors.
- Agriculture and land use, land use change and forestry (LULUCF) are among the most referenced sectors in countries' mitigation contributions (targets and/or actions). The mitigation potential of agriculture and LULUCF is prominently acknowledged by developing countries in all regions and by all economic groupings.
- The agriculture sectors are most often referred to in the INDCs as providing adaptation-mitigation synergies, as well as socio-economic and environmental co-benefits; and Climate-smart agriculture (CSA) is highlighted as contributing to both adaptation and mitigation.

Introduction

A2 – 1.1. Adaptation and Mitigation in the UNFCCC process

International negotiations on climate change initially focused on mitigating climate change, through political agreements to limit emissions of GHG in the atmosphere. In 1992, at the Rio Earth Summit, a global governance on climate was established through the United Nations Framework on Climate Change (UNFCCC). Commitments from countries to reduce their GHG emissions played a central role in the UNFCCC negotiation process, acknowledging the "common but differentiated responsibilities" between industrialized countries and developing countries, as the former have benefited more from past emissions and therefore must take a larger responsibility for future mitigation.

The Kyoto Protocol, adopted in 1997 during COP3, was the first multilateral agreement setting quantified objectives of GHG emissions reduction, binding a limited number of industrialized countries and some being in transition. It was relying partly on creating “carbon markets” – mechanisms that established quotas of GHG emissions that could be traded. A somehow similar market-based approach is being applied to deforestation issues, through the REDD+ mechanism for reducing emissions from deforestation and forest degradation.

Mitigation was the dominant item on the agenda until the late 2000s, mainly addressed through voluntary commitments to reduce GHG emissions from willing countries. However, this approach had limited effectiveness, and GHG emissions in the atmosphere kept increasing dramatically, while impacts of the changing climate was increasingly felt, especially by developing countries, which started to voice a stronger concern on how to adapt to these impacts.

New concepts progressively gained attention, such as adaptation, vulnerability, and resilience. Adaptation became a central part of IPCC reports, and dedicated work streams were developed under the UNFCCC negotiations and its Subsidiary Body on Scientific and Technical Advice (SBSTA). In November 2006 at COP 12 in Nairobi, the SBSTA was mandated to undertake a programme to address impacts, vulnerability and adaptation to climate change, named the Nairobi Work Programme (NWP).

While two work streams were developed in parallel under the UNFCCC, one on mitigation and one on adaptation, with specific concepts, approaches and methodologies; important efforts were deployed by the international scientific community to highlight synergies between mitigation and adaptation, build convergence between these work streams, and ensure that mitigation and adaptation action took place across the spectrum of spatial scales. This led to emerging attention to the concept of adaptation and mitigation co-benefits, of particular importance to the agriculture sectors. Indeed, with sufficient effort, food and agricultural systems can be adapted to climatic changes while also protecting and enhancing natural resources. There is also considerable climate change mitigation potential in many agricultural systems, both in the form of reducing emissions intensity per unit produced, and carbon sequestration in soils and biomass.

The Paris Agreement under the UNFCCC adopted in Paris in December 2015 at COP21 introduced two major shifts in the fight against climate change. For the first time, adapting and building resilience to climate change, and making finance flow consistent with a pathway towards low greenhouse gas emissions and climate-resilient development, are fully-fledged objectives in addition to the objective of mitigating climate change. For the first time as well, efforts to be made by Parties are based on nationally determined (voluntary) contributions with a level of ambition that must keep increasing, instead of an allocation-based approach tentatively binding for countries.

The Intended Nationally Determined Contributions (INDCs) adopted by countries are now calling for a more comprehensive approach to climate change mitigation and adaptation in the agricultural sectors, building on synergies and co-benefits between food production, adaptation and mitigation.

A2 – 1.2. Adaptation and Mitigation in the INDCs

At the UNFCCC Climate Conference (COP21) in December 2015, countries submitted *Intended Nationally Determined Contributions* (INDCs) in which they outlined the effort that their country had the ambition to make towards climate change mitigation and adaptation. The INDCs served as a basis for negotiations at COP21 and provided the foundation for the Paris Agreement on climate change. Unless a Party specifies otherwise, its INDC will become its first Nationally Determined Contribution (NDC) upon submitting its instrument of ratification for the Paris Agreement. INDCs/NDCs outline countries' climate change priorities for the post- 2020 period and include not only targets, but also concrete strategies for addressing the causes of climate change and responding to its effects.

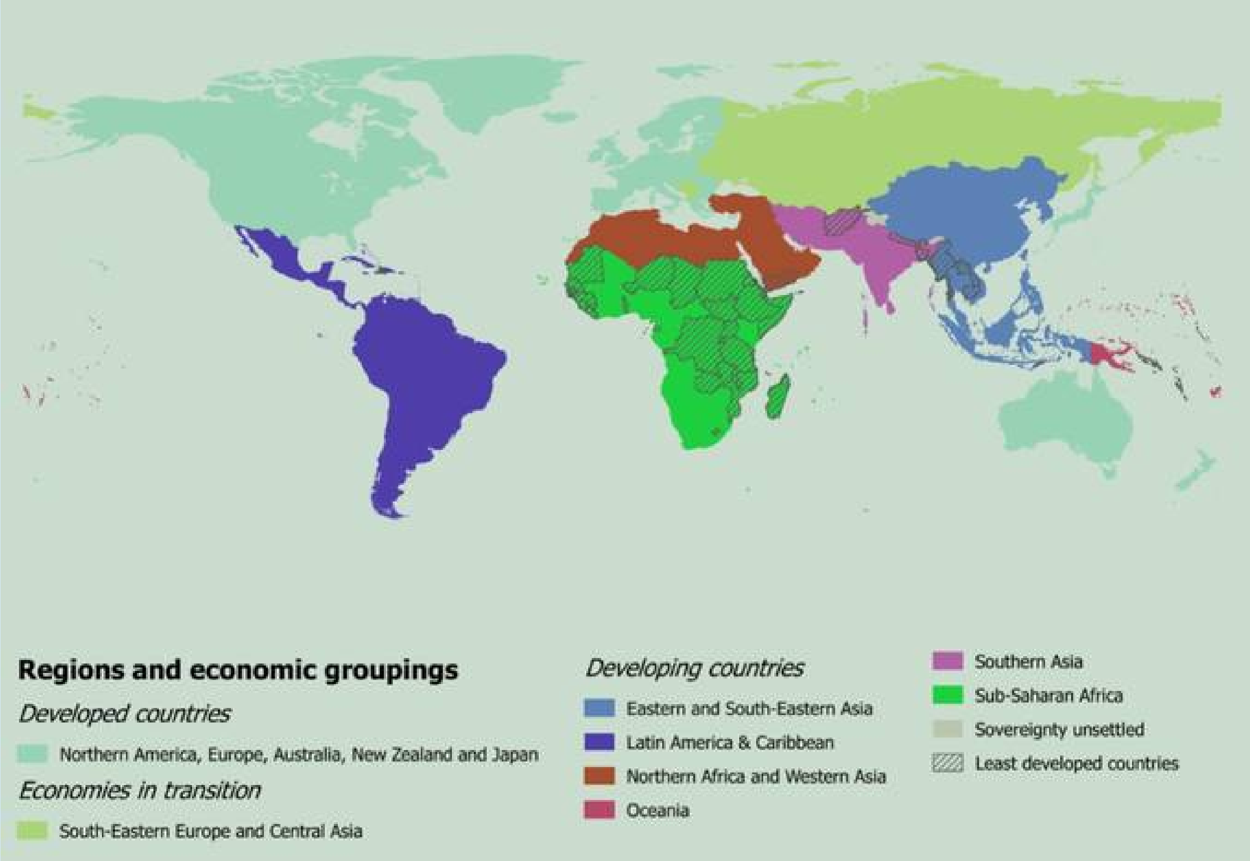
As of 29 July 2016, 189 countries (190 Parties) had submitted a total of 161 INDCs and 22 NDCs to the UNFCCC, 21 of which were originally submitted as INDCs. The information in this module is based on an analysis of these 22 NDCs and 140 remaining INDCs (FAO 2016a). In the remainder of this module, these are collectively referred to as "the INDCs". The INDCs were not prepared according to a standard format. While many Parties followed non-binding guidance, the INDCs are heterogeneous in length, coverage and level of detail. All 189 countries refer to mitigation commitments in their INDCs, while 134 countries include concrete information on adaptation areas and/or actions. Some INDCs (in particular from developing countries) specify detailed measures in specific sectors, while others only point to existing plans for further reference. This heterogeneity calls for caution in comparing country priorities and actions beyond broad patterns. Furthermore, many of the developing countries' INDCs/NDCs are contingent on sufficient external funding being made available to support the implementation of their contributions.

The agriculture sectors (crops, livestock, forestry, fisheries and aquaculture) feature prominently in most countries' national mitigation and adaptation goals – particularly those of the least-developed countries (LDCs). Many of these countries highlight the role of agriculture, forestry, fisheries and aquaculture in economic development, particularly for employment, exports and rural development. Many countries also point to the vulnerabilities of these sectors to climate change. This is a clear signal: the agriculture sectors are central to the global response to climate change and in contributing to sustainable development.

Box A2.1 Methodology and Country Classification

Each INDC was read and analyzed in detail to ensure a comprehensive assessment of the coverage of the agriculture sectors. Original text was extracted into a database, which facilitates the replication and re-examination of the screening process. The data was cross-checked using a keyword search.

Countries were aggregated according to their status of development (least-developed countries, developing countries, economies in transition and developed countries). As the focus of the analysis is on developing countries, these groups were further sub-divided by region.



Source: (FAO, 2016a)

A2 – 1.2.2. Adaptation

The agriculture sectors are the foremost priority for adaptation in the INDCs. Among the 131 countries that include priority areas for adaptation and/or adaptation actions in the agriculture sectors, 127 countries refer to crops and livestock, 116 to forestry and 84 to fisheries and aquaculture. The emphasis on the agriculture sectors is particularly pronounced in Sub-Saharan Africa, where all developing countries point to the agriculture sectors in their adaptation section.126 countries mention Climate-related hazards including extreme events, long-term impacts and increased variability are mentioned by 126 countries in their INDCs. To address these hazards, 95 percent of developing countries include an adaptation section, ranging from 100 percent in Sub-Saharan African and Eastern and South-Eastern Asia, to 79 percent in Oceania.

Countries also highlight the vulnerability of the agriculture sectors to climate change. Of the countries that discuss climate-induced risks at the sector level, most countries mention agricultural production. 74 countries explicitly refer to water resources in the context of adaptation in the agriculture sectors. 54 countries include food insecurity and malnutrition among the major risks they face under climate change.

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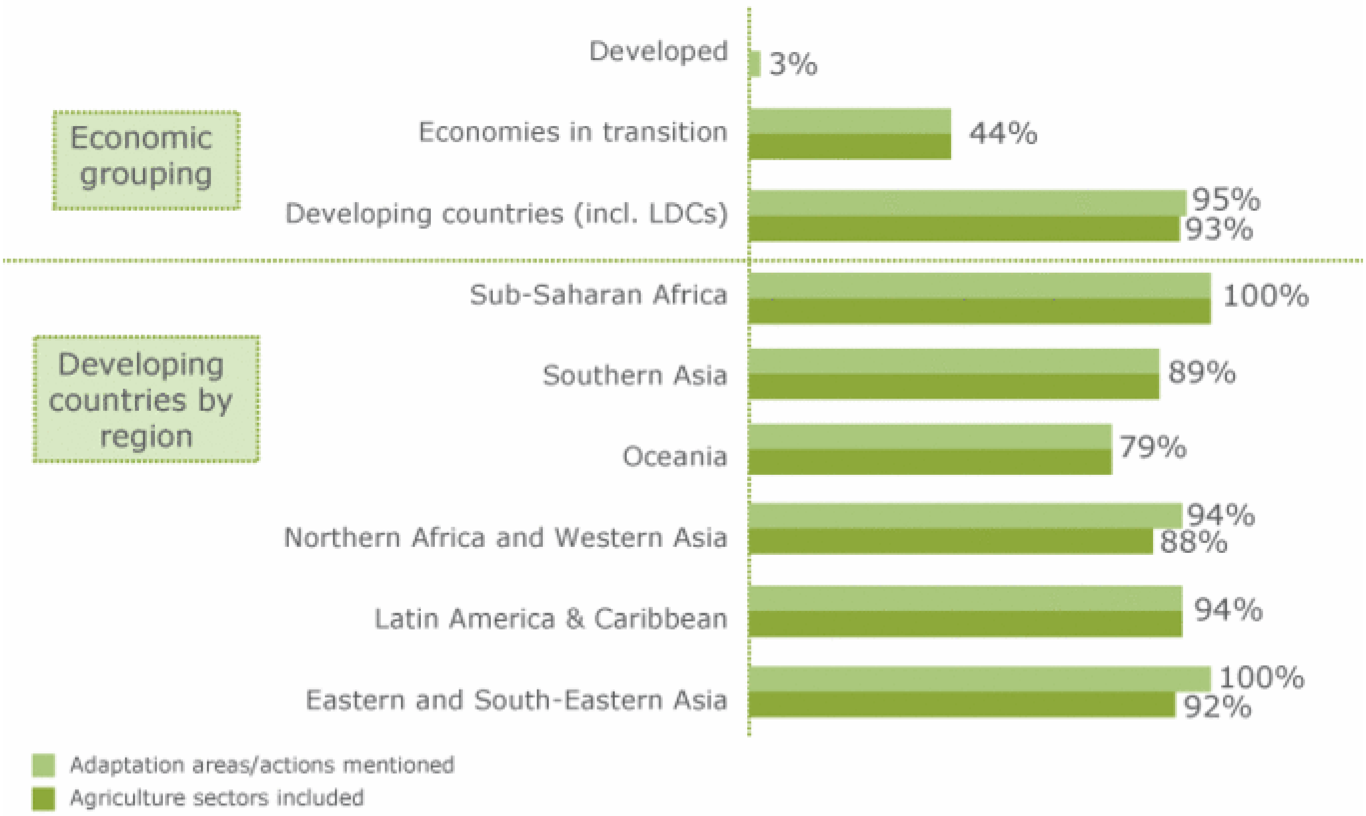
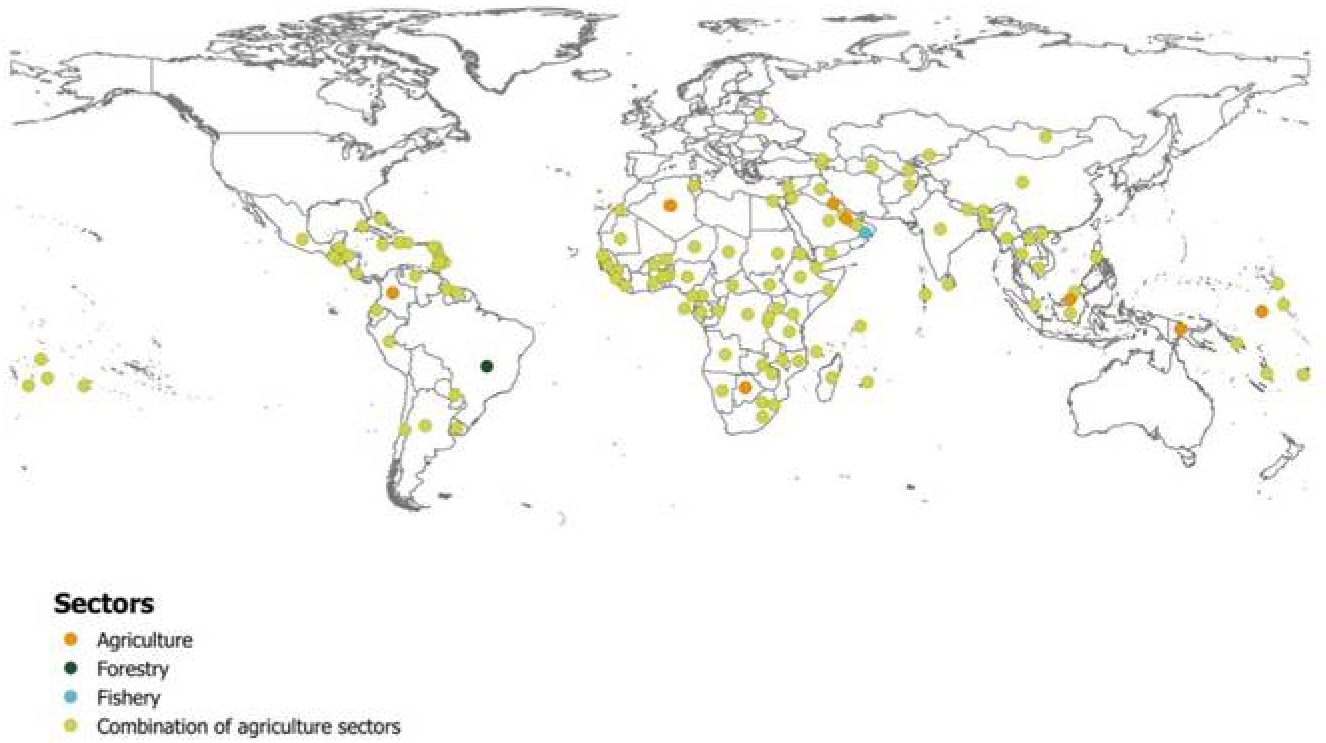
Figure A2.1. Percentage of countries that include adaptation sections and that refer to agriculture sectors in adaptation



Source: (FAO, 2016a)

Most LDCs highlight extreme events as their central adaptation challenge, whereas developed countries emphasize temperature rise. Among the 126 countries that highlight climate-related vulnerabilities, the majority point to extreme events (i.e. droughts, floods) as a foremost threat to the environment and socio-economic development, while almost half of the countries refer to changes in weather patterns. However, there are significant disparities when results are disaggregated by development status: the large majority of LDCs mentions droughts and floods among their immediate threats, whereas developed countries identify the rise in temperature as the major hazard.

Figure A2.2. Reference to the agriculture sectors in adaptation sections



Source: (FAO, 2016a)

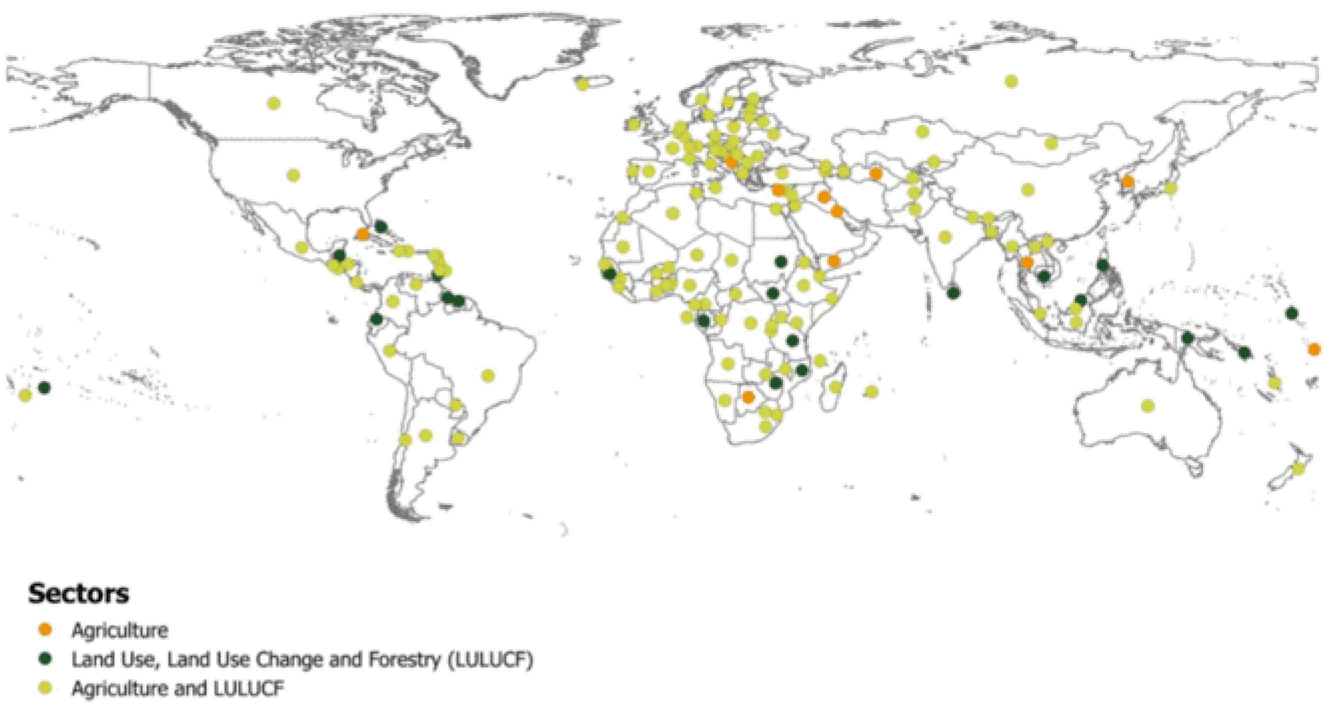
Countries reflect on the importance of disaster risk management in the agriculture sectors. 47 countries mention DRM in the agriculture sectors: 48 percent of the LDCs, 29 percent of developing countries and 29 percent of the economies in transition. Within the different regions, countries in Asia particularly often refer to the agriculture sectors in the context of DRM (62 percent of the countries in Eastern and South-Eastern Asia, 38 percent in Southern Asia). The most common measures include reducing community vulnerability to crisis and disasters and to monitor crisis and disaster risk.

A2 – 1.2.1. Mitigation

Agriculture and land use, land-use change and forestry (collectively referred to as LULUCF) are among the most frequently included sectors in countries' mitigation contributions (targets and/or actions). LULUCF is referenced in 83 percent of all countries' INDCs, and as such is second only to the energy sector. Agriculture is included in 78 percent of countries' mitigation contributions. When considered together, 89 percent of countries cover agriculture and/or LULUCF. When including the countries that mention bioenergy as a mitigation strategy, this percentage increases to 92 percent.

Sector specific targets are rarely quantified in the INDCs, but most countries consider mitigation in agriculture and/or LULUCF as part of an economy-wide GHG target. 86 percent of countries (128 out of 148) include agriculture and 76 percent of countries (120 out of 157) cover LULUCF in their economy-wide GHG target. Many countries specify actions (policies and measures) related to mitigation in agriculture and/or LULUCF. Actions put forward by countries in agriculture focus on cropland management, livestock management and grazing land management. For LULUCF, the actions mentioned by countries can be grouped under forest management and restoration, afforestation/reforestation, and reducing deforestation. The mitigation potential of agriculture and LULUCF is prominently acknowledged by developing countries in all regions and by all economic groupings: 98 percent of developed countries, 88 percent of economies in transition and 86 percent of developing countries (including least developed countries) point to agriculture and/or LULUCF when outlining their mitigation contributions in the INDCs. As illustrated in Figure A2.3, 96 percent of countries in Sub-Saharan Africa refer to these sectors under their mitigation contributions. The corresponding figure in Eastern, South-Eastern and Southern Asia ranges between 89 to 100 percent. Among the Latin American and Caribbean countries, 91 percent refer to agriculture and/or LULUCF in their mitigation section. In Northern Africa and Western Asia, the figure is a more modest 69 percent. In Oceania, the agriculture sectors feature in 50 percent of developing countries' mitigation contributions.

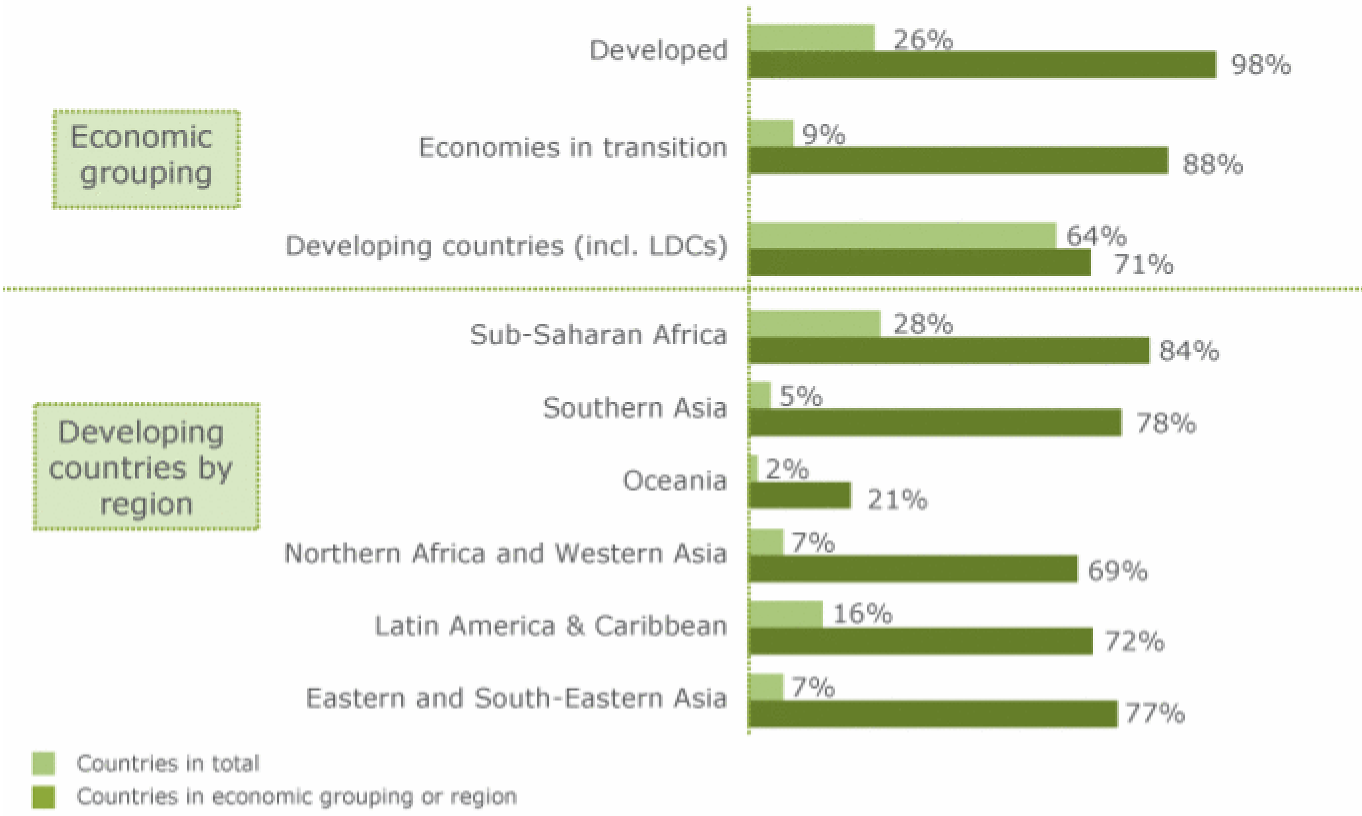
Figure A2.3. Mitigation in Agriculture and LULUCF in the INDCs



Source: (FAO, 2016a)

84 percent of developing countries in Sub-Saharan African refer to mitigation in agriculture (crops and livestock). In most other regions this figure ranges from 69 to 78 percent, with the exception of Oceania where 21 percent of countries do so (see Figure A2.4). 94 percent of developing countries in Sub-Saharan Africa and 85 percent of developing countries in Eastern and South-Eastern Asia refer to LULUCF in their mitigation contributions, indicating an emphasis on forest management in certain regions.

Figure A2.4. Percentage of developing countries indicating mitigation contributions in agriculture (crops, livestock) and LULUCF by region



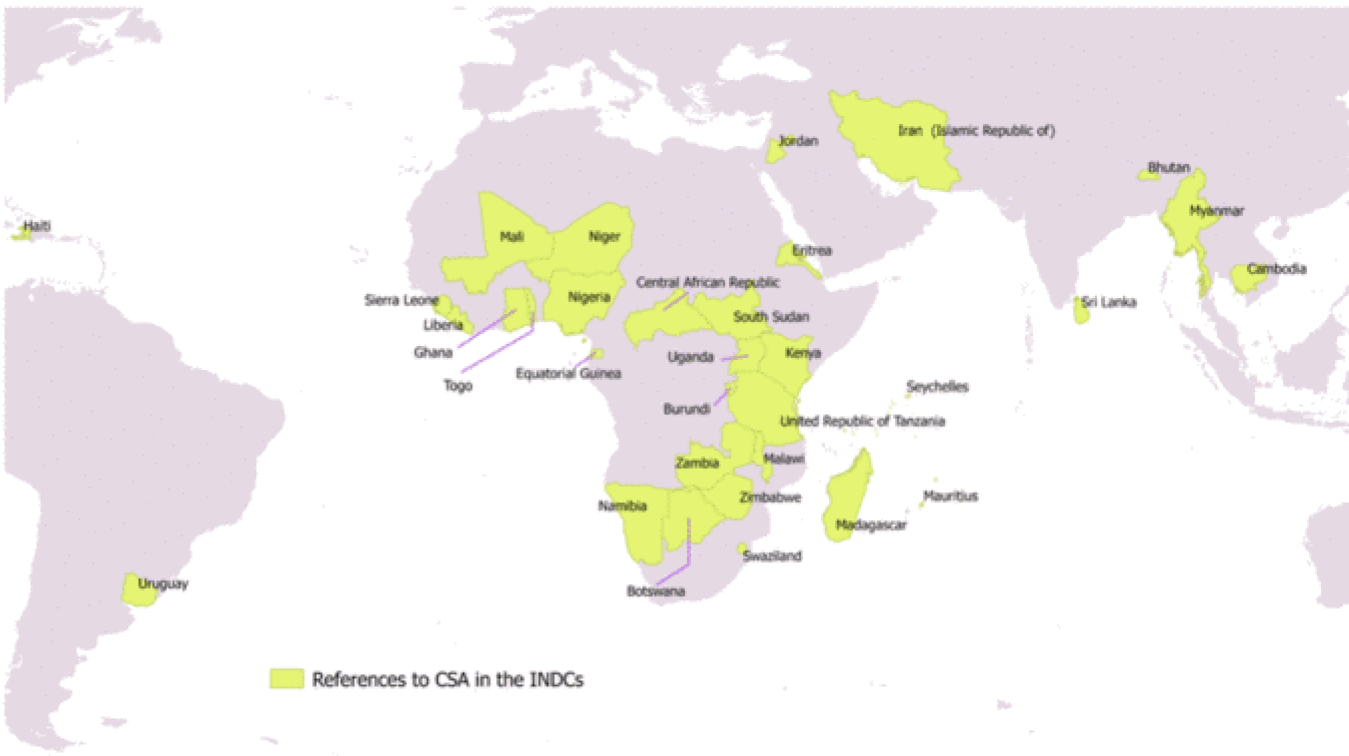
Source: (FAO, 2016a)

A2 – 1.2.3. Synergies and co-benefits

The agriculture sectors are most often referred to in the INDCs as having potential for adaptation-mitigation synergies, with associated socio-economic and environmental co-benefits. Opportunities for realizing these synergies are specified by some countries. Fifty-seven countries endorse or even prioritize actions based on the potential synergies between mitigation and adaptation. Several countries mention social, economic and environmental co-benefits, particularly rural development and health, poverty reduction, job creation, and conservation of ecosystems and biodiversity. With regards to gender equality, the agriculture sectors are highlighted – more so than any other sector – as providing diverse opportunities for empowering women and reducing their vulnerability to climate change.

Climate-smart agriculture (CSA) is highlighted as contributing to both adaptation and mitigation (Figure A2.5). 32 countries, almost half of which are LDCs, specifically refer to CSA in their INDCs. Seventy-five percent (equivalent to 24 countries) of these 32 countries are in Sub-Saharan Africa. The remaining countries are located in Eastern, South-Eastern and Southern Asia (5 countries), LAC (2 countries) and Western Asia (one country).

Figure A2.5. References to CSA in the INDCs



Source: (FAO, 2016a)

A2 – 1.2.4. Need for implementation support

All of the LDCs and more than 90 percent of the other developing countries make their INDCs contingent on receiving financial and technical support. Regarding possible funding sources across various sectors, about 24 percent of all countries mention the Green Climate Fund (GCF). Technology transfer most often relates to renewable energy, energy optimization and mitigation and adaptation technologies and data collection. With regard to capacity building, countries prioritize technical capacities, followed by capacity development for engaging stakeholders, and formulating mitigation and adaptation strategies and policies. Making sufficient financial and technical support available to developing countries to realize the ambition level of the INDCs is one of the major issues facing the global community in the context of the Paris Agreement.

Adapting to climate change

A2 – 2.1. Key concepts and approaches

Adaptation and maladaptation

Adaptation to climate change refers to the process of adjustment to actual or expected climate and its effects (UNFCCC, 2017). And more specifically, as indicated in the fifth assessment report of the IPCC Working Group II (IPCC, 2014a), in some natural systems, human intervention may facilitate adjustment to expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.

Agricultural adaptation is tightly linked to many other cross- or multi-sectoral adaptation issues. Cross–sectoral issues, such as early warning systems, disaster risk management (see module C5), and education and capacity development, are particularly relevant for agricultural stakeholders. It is critical as well to avoid proliferation of any action or process that would increase vulnerability to climate change-related hazards – also known as *maladaptation*.

Maladaptation is the result of sector-based development policies and measures that deliver short–term gains or economic benefits but increase vulnerability in other sectors and/or in the medium to long term (Olhoff and Schaer, 2010). The agriculture sectors are the main users of land and water, and therefore interact closely with other economic sectors competing as well for accessing these increasingly scarce resources. To address some of these issues in medium- to long-term planning and budgeting, countries may choose to formulate and implement National Adaptation Plans (NAPs). The NAP process is conducted under UNFCCC and aims to ensure inclusion and effectively address both complementary but also sometimes competing adaptation needs between different sectors. In that respect, it is meant to be an on-going, progressive and iterative process, following a country-driven, gender–sensitive, participatory and fully transparent approach (for further information on NAPs and related policy frameworks, see module C3). It is also meant to be a cross-sectoral and multi-stakeholder process. It requires to engage all relevant stakeholders, including from all the agriculture sectors, to identify and prioritize adaptation actions, and the allocation of financing pertaining to both development and climate change.

Vulnerability, exposure, adaptive capacity, resilience, and adaptation to climate change

Climate change adaptation should enhance and build on healthy and functional ecosystems, as they provide a variety of benefits and services on which agricultural production systems and rural livelihoods depend. Sustaining these ecosystems is critical to achieving lasting food security and nutrition. The following concept are key to understand and approach climate change adaptation: vulnerability, exposure, adaptive capacity, resilience, and climate change adaptation itself. For these concepts, this sourcebook is adopting either the UNFCCC definition when available (UNFCCC, 2017), or the definition of the fifth assessment report of the IPCC Working Group II (IPCC, 2014b).

- *Vulnerability* refers to the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (UNFCCC, 2017). The fifth assessment report of the IPCC Working Group II defines vulnerability as “the propensity or predisposition to be adversely affected” (IPCC, 2014b). Therefore, vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed (exposure), its sensitivity, and its adaptive capacity. This refers to the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014b).
- *Exposure* is the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
- *Sensitivity* is the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change", but it is not "how affected a system is after the exposure.
- *Adaptive capacity*: In the context of assessments of impact and vulnerability (sometimes termed as outcome vulnerability) that adopt a top-down approach, adaptive capacity is meant as the system’s ability to avoid potential damages, take advantage of opportunities, and cope with the consequences of damages. See also module C5 as the terms also often appear in disaster risk reduction. In the resilience framework (see chapter C8-1.1), adaptive capacity is the capacity of people in a given system to influence resilience. A system may be made more resilient in a number of ways, including: managing human and environmental components in a manner that maintains the system’s status quo (e.g. managing water resources to better cope with drought); or transforming into a new system when the current system becomes untenable (e.g. eliminating irrigation and agricultural production if drought risk is too extreme) (Engle, 2011; Walker *et al*., 2004; Walker *et al*., 2006; Folke, 2006).
- *Vulnerability*: Similarly, the factors considered to influence vulnerability vary according to the approach used. In top-down approaches, vulnerability is considered to result from biophysical drivers. In bottom-up

and contextual approaches the vulnerability of social and environmental resources is assessed in consideration of biophysical factors in context with social, economic, political, institutional and technological factors and processes. Module C8 and specifically chapter C8-1.1 describe the approaches for climate impact assessment including vulnerability and chapter C8.2 on vulnerability assessments.

- *Resilience*: With respect to the term resilience, several definitions are being used in development and humanitarian work, and accordingly in the climate-smart agriculture sourcebook, which tend to share three common elements: (i) the capacity to bounce back after a shock; (ii) the capacity to adapt to a changing environment; and (iii) the transformative capacity of an enabling institutional environment (FAO, 2014). In the specific context of climate change, resilience is the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC, 2014a).

Climate change adaptation actions can be *incremental* when they aim to maintain the essence and integrity of a system or process at a given scale, or *transformational* when they change the fundamental attributes of a system in response to climate and its effects. Incremental changes improve the response to changing conditions little at a time and can be made iteratively, for example adapting planting dates. Transformational adaptation, for example, may involve shifting the system from crop production to a forage based livestock production. Climate-smart agriculture strategies may prompt both types of adaptation actions, which will however require different measures for integration into policy planning and resource mobilization.

With respect to the scope, climate change adaptation options can be grouped broadly in structural/physical, social and institutional categories with a number of sub-categories underneath each.

- *Structural and physical options* are concrete adaptation actions on the ground, at the local or landscape level, for example improved technologies in farming practices or engineering irrigation infrastructure, and integrated natural resources management. These options represent the bulk of the approaches described in the modules in section B.
- *Social adaptation options* reduce vulnerability of social systems and populations, for example that of poor agricultural households by addressing their insufficient access to education, financial services, assets, information, and/or social safeguards. These options are discussed in the modules in section C, and especially in module C5 on disaster risk reduction, module C6 on gender, Module C7 on social protection and decent rural employment.
- *Institutional adaptation options* address the institutional, governance and policy context, for example by improving the laws and regulations that govern sustainable use of resources and facilitates adoption of climate-smart agriculture practices. These options are specifically discussed in module C1 on institutional capacity development and module C3 on policies and programmes.

To identify and implement the most appropriate set of structural, physical, social and institutional climate change adaptation options, two major approaches are available: *community-based* and *ecosystem-based*.

- The *Community-based adaptation approach* is a locally driven process of designing and implementing adaptation actions through assessments of impacts and vulnerabilities, and further screening and appraisal of possible adaptation strategies in a participatory manner. This approach involves relevant stakeholders from different spheres, but always with inclusive local representation, especially of the most vulnerable people. The process aims to empower communities to plan for, and cope with, the impacts of climate change.
- The *ecosystem-based adaptation approach* is looking at building and sustaining healthy and functional ecosystems, as they provide a variety of benefits and services on which agricultural production systems and rural livelihoods depend, and are critical to achieving lasting food security and nutrition. This approach ensures that biodiversity and ecosystem services are considered when designing an adaptation strategy, taking into account nature’s capacity and adaptability to environmental changes (IPCC, 2014a). It involves

stakeholders from various spheres with relevant knowledge, interest or influence to develop and implement adaptation strategies that address the pressures on ecosystem services and resource users, and increases or maintains the resilience of ecosystems and people to climate change.

Both *change management* and *risk management* play roles in adaptation to climate change.

- *Disaster risk management* focuses on preventing, mitigating, preparing for and responding to shocks in short- and medium-term scales. Disaster risk management serves to handle threats such as increased frequency and intensity of extreme weather events and changing patterns of pests and diseases. Strengthening disaster risk management calls for improving local processes and practices for risk reduction and enhancing emergency response and rehabilitation operations;
- *Change management* adds a strategic, long-term objective to policy, legal and research frameworks. Both perspectives are interrelated and mutually complementary, providing incentives to modify behaviors and practices over the medium to long term. Change management in the agricultural sectors consists of several elements, such as legislation, social and institutional development; policies and planning covering cropping, livestock, forestry, fisheries and aquaculture; land, water and genetic resources; livelihoods; integrated farming systems and ecosystems; and linking climate change adaptation and mitigation processes.

When optimizing current conditions and minimizing vulnerability to future changes, trade-offs may occur. For example, converting mangroves into shrimp farms may increase incomes and food supply, but it also may increase vulnerability to climate extremes and climate change. Diversifying agriculture or rural livelihoods builds long-term resilience, but it may decrease income in the short-term. For developing countries, short-term challenges, including immediate climate risks, are often so great that long-term climate risks cannot be given sufficient attention. Designing responses that acknowledge both short- and long-term food security usually requires parallel processes – phased and iterative planning alongside introduction of short- and long-term measures.

Adaptation is not accomplished in a single intervention. Rather, it is a continuum, requiring an overarching approach that incorporates interventions that range from those that address underlying drivers of vulnerability to those designed exclusively to respond to climate change impacts. The vulnerability of a system depends on its exposure and sensitivity to changes, and on its ability to manage these changes.

Climate change adaptation can thus be enhanced by i) altering exposure ii) reducing sensitivity of the system to climate change impacts and iii) increasing the adaptive capacity of the system. Adaptation processes need to be location- and context-specific, integrated and flexible. This is accomplished by basing them on climate monitoring and location and context-specific impact and vulnerability assessments and, at the same time, engaging and working with stakeholders to develop institutional capacity and identify, evaluate, prioritize and select available adaptation options and tools.

In a larger view, adaptation needs to be made an integral part of sustainable development, with climate change implications factored into all development planning, decision-making and implementation. To achieve this goal, the following means and channels can be used to support adaptation in institutions, ecosystems, livelihoods and production systems.

- Mainstream and integrate adaptation fully into agriculture, forestry, fisheries, food security, biodiversity and natural and genetic resource policies, and strategies and programmes at the sub-national, national, sub-regional and regional levels. The goal is to ensure synergy among food security, sustainable development, adaptation and mitigation by raising awareness of links, screening existing development and sectoral policies, strategies and plans through a climate lens, and determining whether they might lead to maladaptation or miss important opportunities arising from climate change.
- Reduce adaptation deficits through development activities in order to reduce vulnerability and lay the foundation for long-term food security through, for example, sustainable increases in agricultural productivity.

- Climate proof all future development plans and interventions by determining whether they are climate sensitive. If so, a more detailed climate risk assessment may be necessary to pinpoint whether they should be amended or if new actions, such as infrastructure development, should be taken to make them more sustainable.
- Enhance adaptation by investing in advocacy and normative work. This can include developing and piloting tools and methods; collecting, analysing and utilizing data and statistics; facilitating information exchanges and communication; advocating and contributing to global, regional and national processes; mainstreaming gender and social considerations in adaptation; preparing manuals and guidelines; and establishing networks and partnerships.
- Promote adaptation through prevention or removal of maladaptive practices, such as those that promote monoculture at the cost of biodiversity. These practices address specific development or short-term adaptation needs and end up being counterproductive with respect to adapting to long-term climate change.
- Work through stand-alone adaptation projects and programmes designed to address specific climate change-induced problems in the agriculture, forestry and fisheries sectors, such as building climate monitoring and impact assessment capacities, diversifying livelihoods, developing entirely new production systems, and promoting urban agriculture.
- Include adaptation as a distinct component of larger programmes, such as multidisciplinary research programmes or institutional capacity development programmes that contain a climate change focus.
- Build the type of capacities institutions need to implement adaptation practices. Adaptation and development are needed in both smallholder and commercial agricultural systems, but they will have significant differences in their priorities and capacities. Commercial systems are chiefly concerned with increasing resource efficiency and reducing emissions. In agriculture-based countries, where agriculture is critical for economic development, adaptation in smallholder systems is important for food security and poverty reduction, as well as for growth and structural change.

A2 – 2.2. Adaptation gaps and needs

A2 – 2.2.1. Enhancing livelihood resilience of smallholder farmers under a changing climate

Most of the world’s poor and hungry are rural people who earn their livings from agriculture. Some 900 million of the estimated 1.2 billion extremely poor live in rural areas. About 750 million of them work in agriculture, 475 million of which as smallholder family farmers (Olinto *et al*., 2013). While 200 million of the rural poor may migrate to towns and cities over the next 15 years, most will remain in the countryside. In that period, the rural population in less developed regions is projected to increase slightly, and an estimated 700 million rural people would be living in poverty. Without great efforts to improve rural livelihoods, the eradication of poverty by 2030 will be impossible (FAO, 2016b).

The smallholder farm families in developing countries face an urgent need to establish livelihoods resilient to impacts of climate change. It will be difficult, if not impossible, to eradicate global poverty and end hunger without building resilience to climate change in smallholder agriculture through the well-planned adaptation through sustainable land, water, fisheries and forestry management practices.

There is an urgent need to scale up adaptation actions to reduce key vulnerabilities of smallholder farming systems to climate change risks, and assess and implement the options for enhancing resilience through sustainable intensification, diversification and risk management strategies. The costs of inaction exceed by far the cost of interventions that would make smallholder farming systems resilient, sustainable and more prosperous.

With other enabling factors in place – such as adequate access to credit and markets, but also action to eliminate legal, socio-cultural and mobility constraints on rural women – those practices have been found to yield significant productivity improvements. However, improved management practices may not be enough to sustain farmer incomes.

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

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

Adaptation to climate change requires making anticipatory adjustments to prepare for expected climate variability and changing average climate conditions, in order to moderate harm and exploit beneficial opportunities. Climate vulnerability is commonly interlinked with poverty and food insecurity, and many synergies can be found between them through climate change adaptation, although not all poverty alleviation efforts constitute effective reduction in climate vulnerability and not all adaptation will automatically lead to immediate improvements in food security.

A2 – 2.2.2. Enhancing adaptive capacity and addressing adaptation deficits

Most ecological and social systems have built-in adaptive capacity. However, the current climate variability and rapid rate of climate change are imposing new pressures that have the potential to overwhelm existing coping capacity. The indigenous knowledge of farmers, forest-dependent people and fishers can be a valuable entry point for localized adaptation. This means recognizing the advantage and capitalizing on locally adapted crops, fish and livestock, farming systems, soil, water and nutrient management, agroforestry systems and vegetation fire management. Nevertheless, in efforts to address complex and long-term problems caused by changing climate, indigenous knowledge often needs to be complemented by scientific know-how.

Adaptation efforts must create the capacity to cope with more frequent, increasingly difficult conditions and gradual changes in climate, even though it often is not possible to anticipate their precise nature. This requires focus on capacity development that strengthens institutions dealing with monitoring, research and extension, as well as social learning, innovation and development processes.

When localized projections of climate change impacts are not available, this will require a “no regrets” approach, which means taking adaptive actions that will be beneficial even if climate change threats do not occur exactly as anticipated.

Production systems with low productivity and high production volatility that make them chronically vulnerable are said to have “adaptation deficits”. Even under existing conditions, these systems produce less, meaning there is a yield gap between their average yields and those of demonstration farms using best practices (FAO, 2016b). They also are less efficient and less resilient to shocks than they could be. Adaptation deficits have arisen, for example, where investments in agriculture have been repeatedly neglected. In such systems, impacts of climate variability and extreme events already reinforce poverty and slow development. That is why it is critical to develop policies and programmes for agriculture, forestry, fisheries and food security that reduce annual climate risk by increasing productivity in a sustainable manner, diversifying rural livelihoods, and increasing local control over resources and decision-making. In this way, they serve current development needs while also preparing ground for the future adaptive capacity.

A2 – 2.2.3. Adaptation costs and finance gap

The costs and benefits of adaptation to climate change have been extensively analysed (e.g. Watkiss, 2015). Estimates vary for many reasons, including differences in regional coverage, climate change scenarios, methods and models, as well as in the time period, adaptation measures and sectors that were considered. Several global studies suggest that the costs of inaction far outweigh the costs of adaptation to climate change (OECD, 2015). Some country-level analyses provide estimates of the costs of inaction side by side with costs of adaptation. For example, a study from Uganda estimates the cumulative economic impacts of climate change on agriculture, water, energy and infrastructure at ranging between US$273 billion and US$437 billion between 2010 and 2050, depending on assumptions about socio-economic development and the severity of climate change (Markandya, Cabot-Venton and Beucher, 2015).

More climate financing and agricultural investments are needed to facilitate the transition to sustainable agricultural practices to enhance adaptation. However, available climate finance for investment in agriculture falls well short of needs. Smallholder producers in developing countries face major hurdles in accessing credit for investing in new technologies and practices, and female farmers even more so. The shortfall in finance limits investment in agriculture and food security and, with it, the capacity of smallholders to adapt to climate change. More climate finance needs to flow to climate-smart agriculture to fund the investment cost associated with the required large-scale transformation of its sectors and the development of climate-smart food production systems. Additional finance from public sources, as well as customized financial products, will be needed in two areas of financing.

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

The assessment of national and sector studies shows that adaptation costs in the period around 2030 are likely to be in the range of US$140-300 billion per annum, whereas international public finance for adaptation in 2014 was around US$22.5 billion. The total finance for adaptation in 2030 would have to be approximately 6 to 13 times greater than international public finance today. Moreover, the potential adaptation finance gap in 2050 would be much larger – in the order of between twelve-to-twenty-two times current flows of international public adaptation finance (UNEP, 2016). The costs of adaptation in the agriculture sector have been receiving increased attention, but there is a gap in assessment that needs to be addressed. Climate finance can also act as a catalyst to leverage larger flows of public and private funding for sustainable agriculture, provided policies and institutional frameworks that promote transformative change are in place.

Climate finance could help address the funding gap by demonstrating the viability of agricultural investments, and designing and piloting innovative mechanisms to leverage additional sources of investment. Climate funds – if used strategically to build the enabling environment essential for adaptation, to ensure that public agricultural investment is climate-resilient, and to leverage private finance – could become an important catalyst for climate change adaptation and mitigation.

By filling the financing gap and catalysing investment, climate finance can strengthen risk management mechanisms, foster development of appropriate financial products, and address the capacity constraints of lenders and borrowers. It is crucial, therefore, to strengthen the enabling environment for investments in agriculture, mainstream climate change considerations in domestic budget allocations and implementation, and unlock private capital for climate-smart agricultural development.

A2 – 2.2.4. Addressing the capacity gap

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

Institutional capacity building and strengthening of organizational networks across all levels and sectors are basic preconditions to making adaptation work. Since adaptation to climate change is a multi-sectoral work, the institutional responsibilities need to be clearly defined. Mechanisms should also be established to coordinate the functions of various agency activities such as planning, communication and operations at field level. Furthermore, it will be crucial to improve links and factor adaptation into other on-going development activities, and to determine clear roles such as who should do what in order to make adaptation effective.

Mitigating climate change

Climate change mitigation aims at stabilizing the greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Paris Agreement, in its Article 2 set this level to 2ºC.

According to the fifth assessment report of the IPCC, mitigation is defined as the “human intervention to reduce the sources or enhance the sinks of greenhouse gases” (IPCC, 2014b). In a broader approach, this definition can be extended to other pollutants and/or atmospheric components, such as black carbon particles, or albedo change due to land-use, all of which contribute to the climate change.

Mitigation results only refer to results from activities that would not have been implemented in the reference or baseline scenario, also called business-as-usual scenario. A baseline is the scenario likely to occur in the absence of any specific intervention to mitigate climate change. This concept is further developed in module C9.

A2 – 3.1. Key concepts, approaches, methodologies and frameworks

A2 - 3.1.1 Key concepts

AFOLU and LULUCF

Agriculture, Forestry and Other Land Use (AFOLU) and Land Use, Land Use Change and Forestry (LULUCF) are categories of activities defined by IPCC in the context of emissions accounting. The AFOLU category includes LULUCF and Agriculture. In the context of mitigation, ‘Agriculture’ – in accordance with IPCC terminology – includes emissions from enteric fermentation, manure management, rice cultivation, prescribed burning of savannas and grassland, and from soils (i.e. agricultural emissions). Emissions related to forest and other land use are covered under LULUCF.

Indirect land-use change

Due to growing use of resources for humanity, for traditional land-use as well as biodiversity conservation and carbon sequestration, the amount of available arable land and forests is limited, and any land-based activity might cause a shift of land-use in another area. For example, conversion of gazing land to cropland could lead to deforestation to new grazing land elsewhere, to meet the demand for livestock production.

Indirect land-use change poses a major risk for the GHG mitigation. As in the above example, any deforestation caused by a CSA activity or policy, directly or indirectly, will result in high GHG emissions which are likely to more than cancel any GHG benefits of the project. It is therefore essential to avoid indirect land-use change or accurately estimate its effect. However, estimating the effect of land-use change can be complex, and it is easier to identify situations in which no indirect land-use change is expected.

Indirect land use change can be avoided if the previous use of the land is integrated with the CSA activity or policy, as is the case of intensification of existing production, or grazing combined with forestry on lands previously used only for grazing. Furthermore, the larger is the area considered, the more likely it is to capture the effect of any indirect land-use change. For this purpose, the evaluation of the GHG emissions and sequestration should be at least on national level, and should ideally include the area from which goods can be conveniently transported. However, considering the international nature of trade in globalized society, indirect land-use change is difficult to capture in a given area.

Double counting

If two policies – for instance one on mitigation (e.g. NAMA) and another one CSA specifically – affect the same geographical area and the same sources and sinks of GHG, it could be difficult to determine which part of the changes in GHG fluxes is to be attributed to which policy, and there is a risk that the entire mitigation outcome would be attributed to both policies, resulting in some of the mitigation outcome being counted twice. To prevent this risk, overlapping policies should be evaluated together as a package of policies. Alternatively, it should be determined in advance how the mitigation outcome be attributed to the policies. It is therefore important to define the scope and physical boundaries of policies to identify such risks of double counting.

A2 - 3.1.2 Approaches to climate change mitigation

To achieve climate change mitigation in the agricultural sectors, it is relevant to develop and implement a range of policies and measures that target all stages of the lifecycle of agricultural products. Module B10 elaborates further on this.

Demand side activities aim to modify the demand for agricultural products. This includes reducing losses in the food supply chain; changing human diets and cooking practices towards less emission intensive products; and reducing demand for wood and forestry products from unsustainably managed forests.

Most agriculture related mitigation methodologies are *supply side methodologies*. There are many opportunities to mitigate greenhouse gas emissions during production, by reducing or avoiding greenhouse gas emissions.

Some demand and supply side approaches in agriculture aim to conserve resources to avoid emissions in the first place, while others focus on increasing carbon sequestration:

- **Reducing/avoiding greenhouse gas emissions**

This category includes policies and measures to reduce or avoid greenhouse gas emissions in the agriculture sectors, such as: improving soils management with conservation agriculture (i.e. no-tillage implemented in the context of varied crop rotations and soil protection/mulching), sustainable use of fertilizers and sustainable mechanization for crop production (see module B1); improving manure management and introducing livestock feed additives in livestock production (see module B2); conservation of forests and their sustainable management in the forestry sector (see module B3); using energy efficient aquaculture and reducing fossil fuel use by fishing fleets (see module B4); sustainably managing soils and lands and avoiding degradation of wetlands (see module B7.

This type of greenhouse gas emission reductions can be effectively evaluated using their emission intensity, rather than the absolute emissions, as these emissions are associated with agriculture products, whose availability is paramount to food security. This is also called relative decrease in greenhouse gas emissions. This rationale takes into consideration that increased production could lead to increased absolute emissions, but nonetheless the increased productivity leads to decreased emission intensity and to products with a lower greenhouse gas footprint. Recognizing the finite amount of produce required, this does lead to overall reduction in emissions.

- **Removing greenhouse gas from the atmosphere**

This category includes policies and measures to increase carbon sequestration in standing biomass and soils. Agro-ecosystems, including forests, naturally remove carbon dioxide from the atmosphere through photosynthesis. The sequestered carbon is stored in biomass and soils, thereby acting as “sinks”. Carbon capture in biomass and soils is generally cost-effective and with few or no associated direct risks, whereas artificial means of carbon capture and storage in subterranean carbon dioxide storage, currently explored, may be more hazardous, in the case of physical leakage or earthquake disturbance for instance. This type of greenhouse gas emission reductions is usually evaluated per area unit, e.g. tonnes of carbon sequestred (or removed from the atmosphere) per hectare per year.Beyond the climate change mitigation benefits, there are numerous other benefits from ecosystem services associated with increasing carbon sequestration in soils and biomass. Many contribute to improved agricultural productivity and climate change adaptation, thus being climate-smart. Improved grazing management can yield greater forage production, increase biodiversity and be a more efficient use of land resources (module B2). Reforestation can prevent soil erosion and provides numerous forest products (module B3).

- **Reducing greenhouse gas outside the AFOLU sector and other effects**

This category includes policies and measures which affect the agriculture sectors as well as other sectors, i.e. energy, industry and waste. It includes activities such as production of bioenergy (module B9), sustainably harvested wood for manufacturing and construction (module B3) and proper disposal of agriculture residues.

Furthermore, this category pertaining to the Agriculture, Forestry and Land-Use sector (AFOLU) includes policies and measures affecting climate change not through greenhouse gas, but rather by modifying the surface albedo or impacting regional climate, both of which can be achieved by afforestation (module B3).

A2 – 3.1.3 Monitoring requirement of GHG and non-GHG effects

Due to the complex nature of any intervention to implement CSA, assessing its impact and monitoring its effects can be complex. Monitoring is required to quantify the results, to ensure permanence of the mitigation effort, as well as to ensure there are no adverse effects elsewhere in the biosphere. To ensure effective monitoring, on top of all relevant GHG streams, major co-benefits and associated risks must be identified, and adequate monitoring scheme implemented. For example, if biomass is used to produce energy, on top of the land use and energetic use related parameters, it is also necessary to monitor water use and possible groundwater contamination, to ensure that water use is sustainable. Furthermore, the possibility of indirect land use change must also be investigated, as production of energy crops could compete with food production.

A2 – 3.1.4 Approved Methodologies and Frameworks

Mitigation in the AFOLU sector is measured following the IPCC methodology as detailed in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). Three IPCC methodologies are relevant:

1. The generic IPCC methodology, which simply multiplies an activity data with an emission factor, resulting in GHG emissions or removals. The activity data, which measures the magnitude of the activity. This could be the affected land area, harvested wood volume, livestock population, amount of fertilizer used, waste management system specifications. The emission factor, which indicates the emissions, emission intensity or organic carbon stock associated with the policy or activity reviewed or their baseline scenario.
2. The gain and loss methodology, through which estimating the net carbon stock change of C pools as biomass, by adding all the gains and losses of carbon stock during the relevant time period. This methodology requires comprehensive inclusion of all carbon gains and losses to be effective. It is used for forestry projects as a default method.
3. The stock difference method, which estimates carbon stock change by comparing the carbon stock in two points in times, as for Soil carbon in mineral soils. The resulting carbon stock change is then divided by the considered time period, to result in an annual carbon stock change value. This methodology is usually used for non-forestry land use, such as cropland, and grassland, as well as for land use change. It is used for forest land in case a country exist of a national forest inventory with repeated measurements.

When applying the above methodologies, various activity data and emission factors are required. Whereas activity data always have to be measured, activity data can have several sources, categorised in three tiers.

Tier 1 approach implies using IPCC default emission factors, which are applicable world-wide. It is highly inaccurate, and is usually used only for rough estimation of the effect of a policy or activity. For a realistic estimation, for example for a national inventory, a higher tier approach is needed.

Tier 2 approach uses country specific emission factors, or even sub-regional emission factors, and applies them in the IPCC methodology. It is results is a better estimate of the GHG emissions and sequestration. The emission factors are either determined by a national measurement effort, which could be a survey, direct measurements or remote sensing analysis. Alternatively, it can be taken from recognized databases which collect verified emission factors. The relevant measurement approaches and existing databases are included in their respective chapters of this sourcebook.

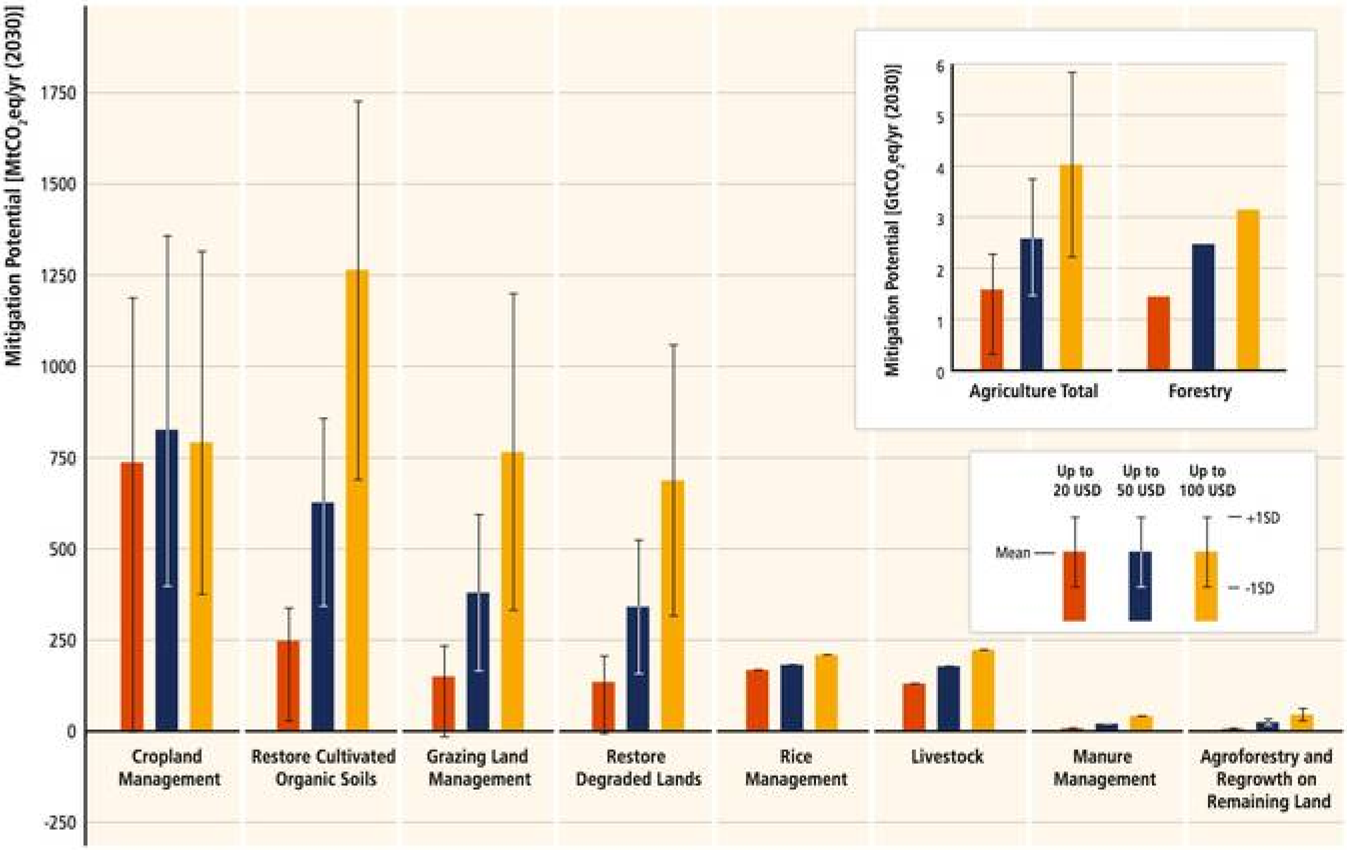
Tier 3 approach uses methodologies and emission factors developed specifically for national circumstance. It is the most accurate approach for estimating GHG emissions and sequestration, but it requires effort to develop and maintain. The methodologies are not automatically transferable to other national circumstance, and therefore tier 3 approaches are not generally included in this publication for use by CSA policies and activities.

A2 – 3.2. Mitigation potential and cost

The AFOLU sector is important for the global GHG mitigation strategy, as it encompasses many cost-effective means of mitigation. When considering cost-effective mitigation potential, it should be known at what net cost the mitigation action can be implemented. Considering this, the combination of forestry and agriculture are estimated to have a potential for mitigating 3 $GtCO_2$ per year with a carbon price at 20 USD/tCO_2, and 7 $GtCO_2$ per year at 100 USD/tCO_2. Production efficiency worldwide has been improving in recent years, and implementation of CSA could further reduce net emission intensity of AFOLU commodities. The mitigation potential for the AFOLU sector is further described in Figure A2.6 hereinafter.

Figure A2.6. Mitigation potential for the AFOLU sector, plotted using data from AR4

Whiskers show the range of estimates (+ / - 1 standard deviation) for agricultural options for which estimates are available (source: IPCC, 2014c).



Nabuurs et al., 2007; Smith et al., 2014).

Each region has different potential, depending on its geographic and climatic conditions as well as the socio-economic situation and the production taking place in it. When designing interventions following a CSA approach, activities relevant in the region and with low net cost of implementation should be pursued by seizing local opportunities and co-benefits, to ensure climate-smart agriculture with effective and cost-effective mitigation impact. For instance, according to the IPCC's fifth assessment report, for the forestry sector (discussed in module B3), reduced deforestation is most effective in Latin America, Central Africa and the insular Asia, whereas in continental Asia and in Northern Africa have the highest potential for afforestation and reforestation, and in the OECD countries forest management would be more effective (Smith *et al*., 2014). Also, rice management (explained in module B1) is a relevant activity almost exclusively in Asia, whereas grazing land management (addressed in module B7 on sustainable soil management and module B2 on livestock production) is relevant almost in any context.

A2 – 3.2.1 Cost of implementation

When considering mitigation potential, it should be known at what net cost the mitigation action can be implemented. Mitigation costs vary largely between agriculture commodities and also depend on country contexts such as production, production potential, demand and lifestyle. When considering the cost of implementation in terms of mitigation, the various costs and financial benefits throughout the production chain, such as implementation of the action, increase/decrease in resource needs (soil, water, fertilisers, additives, fuel) and sources of income, are added and divided by the expected emission reductions, to get an estimate of the cost it would take to mitigate emission of one tonne CO_2 eq.

As a general remark, the agriculture sectors are important for the countries' greenhouse gas mitigation strategies, as they encompass many cost-effective means of mitigation. Specifically, to ensure an optimal mitigation outcome, countries may choose to focus climate change mitigation efforts on the agriculture sectors that contribute most to national greenhouse gas emissions and for which large mitigation potential has been identified.

Mitigation costs vary largely between AFOLU commodities. For example, in rice and cereal production, mitigation cost is around 25 USD/tCO_2, 110 USD/tCO_2, for cattle meat production and as high as 330 USD/tCO_2 for milk production. Mitigation activities in forestry might be cost effective without financial support.

Conclusions

Over the year, the UNFCCC negotiation process has led to a major distinction between mitigation and adaptation, as two work streams with specific concepts, approaches and methodologies.

However, particularly in the agricultural sectors, there are many synergies and interactions between what is usually considered under mitigation and what is usually considered under adaptation. The work streams and mechanisms established so far under the UNFCCC have not always enabled such considerations.

The Intended Nationally Determined Contributions (INDCs) adopted by countries are now calling for a more comprehensive approach to climate change mitigation and adaptation in the agricultural sectors, building on synergies and co-benefits between food production, adaptation and mitigation.

More broadly, such an approach is needed to be able to address simultaneously the challenges pertaining to food security and climate change.

There is increasing scientific evidence of the potential advantages of adopting CSA as a comprehensive approach to simultaneously address objectives pertaining to food production, adaptation and mitigation, while maximizing synergies and minimizing trade-offs. However, mainstreaming such an approach requires:

- for farmers, fishers, foresters, herders and other rural people to see tangible advantages in terms of higher incomes, reduced costs or labour and sustainable livelihoods. These issues are addressed in the second section of this sourcebook, focusing on production (climate-smart agricultural production) and resources (climate-smart use of natural resources and energy);
- and for policy-makers to design and implement supportive policy frameworks that include incentives, address climate change issues and rural development, and foster synergies between multiple benefits through the sustainable transformation of agriculture. These issues are addressed in the third section of this sourcebook, focusing on enabling frameworks for CSA.

It is now critical to both support countries with comprehensive approach such as the CSA one *vis-à-vis* their INDCs, and find ways to develop such approaches to enhance synergies and co-benefits through the instruments established under the UNFCCC.

Acknowledgements

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Contributing authors: Martial Bernoux (FAO), Hideki Kanamaru (FAO), Marwan Ladki (FAO), Selvaraju Ramasamy (FAO), Julia Wolf (FAO).

Reviewers: Paola Cardenas-Galindo (FAO), Rocio D. Cóndor Golec (FAO), Sandro Federici (CBC), Claudia Garcia (FAO), Alashiya Gordes (FAO), Donagh Hennessy (FAO), Esther Mertens (FAO), Dirk Nemitz (UNFCCC), Mirella Salvatore (FAO).

Notes: New module

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