Food and Agriculture Organization of the United Nations

Tracking adaptation in agricultural sectors

Climate change adaptation indicators

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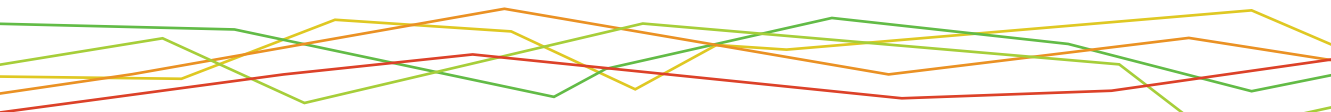

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Abbreviations and acronyms

AMAT	Adaptation Monitoring and Assessment Tool
CBA	Community-Based Adaptation
CCA	Climate Change Adaptation
CIF	Climate Investment Funds
CRM	Climate Risk Management
EAA	Ecosystem Approach to Aquaculture
EAF	Ecosystem Approach to Fisheries
EEA	European Environment Agency
ETC/ACC	European Topic Centre on Air and Climate Change
FAO	Food and Agriculture Organization of the United Nations
FRA	Global Forest Resources Assessment
GDP	Gross Domestic Product
GDPRD	Global Donor Platform for Rural Development
GEF	Global Environment Facility
GEMS	Global Environment Monitoring System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German International Cooperation Agency)
IDB	Inter-American Development Bank
IDS	Institute of Development Studies
IIED	International Institute for Environment and Development
IMF	International Monetary Fund
INFORM	Index for Risk Management
IPCC	Intergovernmental Panel on Climate Change
ISPA	Interagency Social Protection Assessments
IUCN	International Union for Conservation of Nature
LDCF	Least Developed Country Fund
LDCs	Least Developed Countries
LEG	Least Developed Countries Expert Group
M&R	Monitoring and Reporting
NAPs	National Adaptation Plans

NAPAs	National Adaptation Programmes of Action
NDCs	Nationally Determined Contributions
NFMA	National Forest Monitoring and Assessment
OECD	Organisation for Economic Cooperation and Development
PDNA	Post Disaster Needs Assessment
PEG	Tool for monitoring Progress, Effectiveness, and Gaps
PMERL	Participatory Monitoring, Evaluation, Reflection and Learning
PPCR	Pilot Programme on Climate Resilience
P/PET	Precipitation/Potential Evapotranspiration
RIMA	Resilience Index Measurement and Analysis
SCF	Strategic Climate Fund
SCCF	Special Climate Change Fund
SFDRR	Sendai Framework for Disaster Risk Reduction
SGDs	Sustainable Development Goals
SHARP	Self-evaluation and Holistic Assessment of Climate Resilience of Farmers and Pastoralists
Sida	Swedish International Development Cooperation Agency
SIDS	Small Island Developing States
SNAP	Stocktaking for National Adaptation Plans
TAAS	Tracking Adaptation in Agricultural Sectors
TAMD	Tracking Adaptation and Measuring Development
UKCIP	UK Climate Impacts Programme
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNECE	Economic Commission for Europe of the United Nations
UNEP	United Nations Environment Programme
UNISDR	United Nations Office for Disaster Risk Reduction
UNITAR	United Nations Institute for Training and Research
UNFCCC	United Nations Framework Convention on Climate Change
WB	The World Bank
WDI	World Development Indicators
WTO	World Trade Organization

Summary

Tracking adaptation progress at country level is increasingly recognized as an important element of climate change adaptation. The Paris Agreement, adopted in 2015, stresses the need to monitor and learn from adaptation actions, and recommends periodical stocktaking of the overall progress towards climate change adaptation.

Tracking progress towards climate change adaptation is a relatively recent yet rapidly expanding field. Several initiatives, guidelines and frameworks have been launched at the national and global level. However, the literature on adaptation tracking frameworks identifiescertain challenges and limitations with respect to their application in agricultural sectors (crops, livestock, forestry, fisheries and aquaculture). Though some of the tools are technically sound, their practical use is constrained by the absence of adequate baseline information. In addition, several frameworks and methods are project-specific, and can therefore contribute only partially to policymaking at the national level.

This paper outlines a framework and methodology for Tracking Adaptation in Agricultural Sectors (TAAS) at the national level. The framework recognizes the complex nature of adaptation processes across agricultural subsectors. It provides a clear understanding of the interrelationships between natural resources and ecosystems, agricultural production systems, socio-economics and institutional and policy systems that drive adaptation processes and outcomes.

The TAAS framework and methodology examines processes and outcomes of adaptation at national and local levels, providing a consistent and flexible list of indicators. It builds on existing indicators of sustainable development, climate change adaptation and disaster risk reduction, to avoid any duplication of tracking efforts at the national level. Four major categories of indicators are identified: natural resources and ecosystems, agricultural production systems, socio-economics, and institutions and policies.

Indicators related to natural resources and ecosystems reflect the state of the environment and its functioning and interactions with agriculture. Indicators related to agricultural production aim to monitor the interaction between natural resources, ecosystems, agricultural production systems and climate change impacts, and these indicators reflect the degree to which agriculture production systems are capable of producing desired outputs in a sustainable manner.

Socio-economic indicators help understand the relationships between climate change adaptation and socio-economic development. These indicators include information about food security and nutrition, access to basic services, access to credit, insurance, social protection, agricultural value addition, income and livelihood diversification. Indicators related to institutions and policymaking reflect the degree to which institutions are capable of formulating and implementing effective adaptation policies and strategies for the agricultural sector.

These four major categories of indicators cut across the key entry points for adaptation, including vulnerability reduction, adaptive capacity enhancement and mainstreaming of climate change concerns into sectoral policies. Relevant adaptation indicators can be identified based on a review of existing data and information, and agreed upon by all stakeholders engaged in the process. The scope and number of indicators can be adapted during the tracking process in order to meet evolving reporting needs.

This paper identifies four subcategories for each of the four main categories of indicators, bringing the total number of indicator subcategories to sixteen. It proposes an indicative list of process- and outcome-based indicators relevant to agriculture, for context-specific adaptation tracking. Generally, most process-based indicators are qualitative, and most outcome-based indicators quantitative. The methodology includes a scoring procedure, whereby indicators are given scores from 0 to 10, converted from raw quantitative and qualitative data. The scoring system matches the six levels of adaptation progress: very low, low, moderate, high and very high.

In order not to impose unnecessary demands on countries' data collection and reporting efforts, the indicative list of indicators takes account of ongoing national efforts for reporting to major international mechanisms (including the UN's Sustainable Development Goals and Sendai Framework for Disaster Risk Reduction) and existing data from various sources. The choice of indicators depends on users' needs and the relevance and availability of data.

The tracking methodology is meant to be applied at the national level. However, it is flexible enough to be adapted to context-specific situations at the local level, depending on the availability of data. The framework and methodology described in this paper aims to assist countries in their ongoing efforts to develop systems to track climate change adaptation. In a next phase, detailed guidelines should be developed for the implementation of the tracking methodology at national level.

1. Introduction

1.1 Climate change adaptation context-specific actions

Climate change adaptation refers to changes in processes, practices and structures to moderate potential damages from climate change, or to benefit from opportunities associated with such changes.[1] Adaptation in agricultural sectors (crops, livestock, forestry, fisheries and aquaculture) signifies modifying natural, agricultural production, socio-economic, institutional systems and policymaking in response to and in preparation for actual or expected climate variability and change and their impacts, to moderate harmful effects and exploit beneficial opportunities.

The 2015 Paris Agreement promotes climate change adaptation as one of its key goals by enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development. In its aim to achieve a global response to climate change to protect people, livelihoods and ecosystems, the agreement takes into account the needs of developing countries, which are particularly vulnerable to the adverse effects of climate change (UNFCCC, 2015a).

Climate change adaptation is of paramount importance to agriculture, given the reliance of the sector on climate. Climate change adaptation policies should be based on science, and incorporate knowledge of indigenous peoples and traditional practices. Adaptation considerations should be mainstreamed into sectoral and cross-sectoral policymaking, and promote good adaptation practices to confront the heterogeneity and uncertainty of climate change impacts. Ultimately, adaptation efforts should contribute towards sustainable food production and food security for all.

[1] "The adaptation processes" from UNFCCC [Cited 24 September 2017]. available at http://unfccc.int/focus/adaptation/items/6999.php.

Multiple and integrated adaptation measures cutting across agricultural sectors are essential, as is the need to take particular account of vulnerable ecosystems and communities, including smallholders. Any concrete action should be country-driven, gender-responsive, participatory and fully transparent.

The degree to which agricultural sectors are vulnerable to the impact of climate change is location-and context-specific. Programmes aimed at reducing climate change vulnerability and/or enhancing adaptive capacity should therefore be location-and context-specific, too.

Innovation and technology transfer are instrumental to context-specific climate change adaptation. There is a strong need to strengthen research and development linkages and ensure the transfer of location-specific technologies and practices.

Effective adaptation actions require strong institutional and technical capacities, inter-organizational networking and cooperation with clearly defined roles and responsibilities, and firm policy commitments. The development of successful agricultural adaptation strategies calls for a high level of cooperation and information-sharing (of scientific knowledge, and of best practices and experiences in adaptation planning, policymaking and implementation) among various actors. Strong public-private partnerships may contribute towards the reduction of climate change vulnerability and the enhancement of adaptive capacity at all levels.

Climate change adaptation involves public and private actors at different spatial (e.g. households, communities, regional and national authorities) and temporal (e.g. seasonal, annual, decadal) scales. The monitoring of adaptation processes, investments and outcomes at these various scales is crucial to evidence-based decision making and adaptation capacity enhancement in agriculture.

1.2 The rationale for tracking adaptation processes and outcomes

In this paper, "tracking" refers to the monitoring of adaptation processes and outcomes along a continuum. Tracking requires the continuous collection of data and information to enable stakeholders to check whether adaptation processes and outcomes are in line with stated objectives.

The need to track adaptation processes and outcomes at the national level is growing. Indeed, specific needs have emerged in the context of the Paris Agreement:

- The countries need to submit and periodically update adaptation communications to the United Nations Framework Convention on Climate Change (UNFCCC) (which may include priorities, implementation and support needs, plans and actions), as a component of or in conjunction with other communications or documents, including national adaptation plans (NAPs) and nationally determined contributions (NDCs).
- The global stocktaking exercise proposed under the Paris Agreement may also include the tracking of national efforts towards the enhanced implementation of adaptation actions at national, subnational and local levels.
- The Paris Agreement highlights the need to share scientific knowledge and information related to adaptation planning and implementation. This requires sector-specific frameworks to track adaptation.
- Tracking is also crucial to evaluate whether implemented adaptation actions have contributed towards the objectives of reducing vulnerability, enhancing adaptive capacity and increasing resilience.

At the national level, the information generated as part of the tracking process can help to raise broader political and financial support for adaptation efforts. Thus, adaptation tracking is instrumental to:

- the identification of agriculture-specific adaptation practices, needs, challenges and gaps, with a view to encouraging good practices and improving the effectiveness and sustainability of adaptation actions; and
- the implementation of adaptation actions to reduce vulnerability, strengthen adaptive capacity and enhance resilience to climate-related risks within broader sustainable development strategies.

1.3 Purpose and scope of the document

There is a growing need for coherent frameworks and analytical methodologies to track adaptation in agricultural sectors at the national level. Although there exist several frameworks and methods to monitor adaptation processes and their outcomes at the national level, as well as the outcomes of adaptation actions at the local level (see Annex 2), these tools are not agriculture-specific. In addition, they do not adequately capture the interlinkages between adaptation processes and outcomes in agricultural sectors and their effects on food security and nutrition.

This document provides a framework and methodology specifically designed to monitor climate change adaptation at the national level, by ministries responsible for agriculture, livestock, forestry, fisheries and aquaculture. The framework may be customized to monitor adaptation at the local level, whenever granular data are available. The target audience of this document is national decision makers and planners in agricultural sectors, as well as other stakeholders, including development partners, research institutions and adaptation practitioners, involved in tracking adaptation progress.

The paper first analyses the rationale and principles behind tracking adaptation processes and outcomes, and identifies a number of challenges. It then provides a conceptual and operational framework to track adaptation in agriculture, and presents a flexible tracking methodology and step-by-step procedures to apply the conceptual framework.


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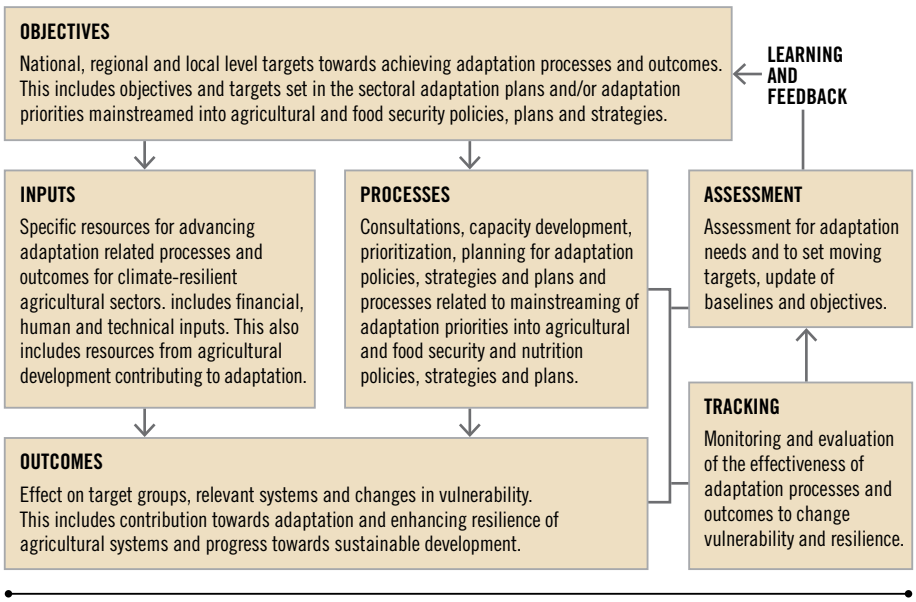
2. Tracking adaptation

2.1 Tracking
a continuous and iterative process

Figure 1 shows the key elements of adaptation tracking, represented as a continuous and iterative process due to changing climate drivers and risks (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2015). Setting clear and achievable objectives and targets, securing the required inputs and creating an enabling environment are all essential to achieve the desired outcomes.

(Multi)sectoral adaptation initiatives and agricultural development programmes may provide inputs (e.g. financial and human resources, technical capacities) into adaptation processes.

FIGURE 1. THE MAIN ELEMENTS OF TRACKING ADAPTATION PROCESSES AND OUTCOMES



Tracking inputs, enabling processes and outcomes is key to understanding adaptation processes' effectiveness in reducing climate change vulnerability and enhancing adaptive capacity. This analysis should feed into a systematic assessment aimed at identifying further adaptation needs and objectives, based on new baselines and targets. Tracking and assessment may also directly contribute to adjustments in inputs and processes, without the setting of new objectives, baselines and targets.

2.2 Tracking the components of adaptation

Adaptation activities span across five general components: the observation of climatic and non-climatic variables; the assessment of climate impacts and vulnerability; planning; implementation; and monitoring of adaptation actions.[2] Successful adaptation requires the active and sustained engagement of stakeholders (such as national, regional, multilateral and international organizations, the public and private sectors, and civil society), and effective knowledge management.

Frameworks to track adaptation in agriculture must capture all five general elements of adaptation activities:

→ **Observation of climatic and non-climatic variables.** The observation over space and time of climatic and non-climatic stressors relevant to agriculture is a prerequisite for the initiation of vulnerability and impact assessments and adaptation planning. Relevant data may include terrestrial and aquatic observations, information on the state of agricultural and food systems, agro-environmental variables, observed impacts of climatic stressors, and socio-economic variables. The latter category includes non-climatic stressors such as population growth, poverty and food insecurity, which exert pressure on natural resources, ecosystems and production systems. The collection, archiving and analysis of relevant data on climatic and non-climatic variables are part of the observation element of the adaptation process.

2 "Elements of Adaptation - Adaptation activities span five general components: Observation of climatic and non-climatic variables, assessment of climate impacts and vulnerability, planning, implementation, and monitoring and evaluation of adaptation actions" from UNFCCC [Cited 24 September 2017]. available at http://unfccc.int/adaptation/items/7006.php.

- **Assessment of impacts, vulnerability and risks.** Climate change may impact: natural resources and ecosystems (for example by altering water availability, which affects agriculture, and food security in all four of its dimensions: food availability, food accessibility, food utilization and food systems' stability), livelihood assets and productive infrastructure, and plant and animal health (for example by increasing temperatures, which facilitates the spreading of pests and diseases). The assessment of the vulnerability of ecosystems or communities to climate risks and their impacts contribute to planning and implementation of adaptation actions.
- **Adaptation planning and mainstreaming.** This involves the identification and assessment of adaptation options to reduce climate change risks and vulnerabilities, and their integration into national and sector-specific policies, strategies and plans. The mainstreaming of adaptation into agriculture sectoral and broader development planning helps avoid duplication of adaptation efforts. Meanwhile, spillovers from adaptation actions implemented in other sectors (e.g. health or education) may influence the outcomes of adaptation actions in the agricultural sector. Adaptation planning must be based on sound analysis of social and gender (women, men, boys and girls) issues that influence adaptive capacity and access to adaptation technologies.
- **Implementation of adaptation measures.** Implementation takes place at various levels (national, regional or local) and through different means (projects, programmes, policies or strategies).
- **Monitoring and Evaluation**: Progress towards adaptation should be monitored across all adaptation processes and components (observation, assessment, planning and implementation). The monitoring and evaluation should capture both stand-alone actions and actions fully integrated (mainstreamed) into sectoral policies and sustainable development plans. Tracking should ensure that monitoring and evaluation systems of adaptation projects, programmes and actions are adequately developed and implemented. Ultimately, the monitoring and evaluation systems should allow development partners to draw lessons and improve future adaptation actions.

2.3 Challenges of tracking adaptation

Adaptation tracking is a complex process. Challenges of the tracking processes are highlighted widely in the literature (Lamhauge *et al*., 2012; EEA, 2015; Bours *et al*. 2014a; Price-Kelly *et al*. 2015). The main challenges are described below:

Baselines change over time. The points of reference against which adaptation progress may be measured (baselines) change over time. Baselines are also determined by certain developmental objectives. For example, projected change in crop production compared to a baseline, which is determined based on food security related objectives.

Several interventions and under-reporting. Multiple development interventions may influence a community's climate change vulnerability, resilience and adaptive capacity. The projects and programmes that explicitly target climate change adaptation are still relatively recent. On the other hand, adaptation interventions by private actors may go under-reported.

No one universal indicator for adaptation. There is no universal adaptation objective, nor are there universal indicators to measure progress towards adaptation. Indeed, which variables should be monitored and evaluated varies from one case to the next.

Many actors having different requirements. Adaptation efforts may involve actors at varying levels across multiple sectors. Different stakeholders may have different requirements, leading to the creation of multiple monitoring and information exchange systems. This inflates the costs of data gathering and analysis.

Difficulty of attribution of specific policies and actions to outcomes. Attributing outcomes to specific policies and actions can be challenging, as adaptation is slow, uncertain and often achieved through policies with broader development objectives.

Diversity of adaptation objectives. Different adaptation efforts may have varying objectives, and thus tracking frameworks should capture all these objectives. They may aim to reduce climate change vulnerability; enhance adaptive capacity; or strengthen institutions and policies with a view to reducing the risks posed by climate change.

Uncertainty of the climatic and non-climatic drivers and risks. The uncertain and dynamic nature of the various climatic, social and economic drivers that influence climate change vulnerability makes it difficult to evaluate the appropriateness of adaptation policies and actions. The impacts of climate change are highly uncertain; thus, the identification of long-term adaptation targets and the corresponding modification of infrastructure and institutions are complex.

Longer and shorter timeframes of impacts and adaptation. Climate change is a long-term process, stretching beyond the timespan of individual programmes and policies. However, climate change may have both long- and shorter-term impacts. The appropriateness of adaptation actions may therefore only be understood after many years.

Lack of data and information for tracking. Adaptation tracking often requires combining data gathered for other purposes, which may result in a mismatch of data types according to methodology, format, spatial or temporal scale, or granularity. In many countries, the quality and availability of data is often lacking. A selection of indicators that does not correctly target the adaptation goals may lead to inappropriate monitoring. In some cases, there is a risk of data overload and thus monitoring processes should therefore be kept simple.

High costs of data collection. The resources available to collect and analyse data and information on adaptation are often limited. This means that compromises must be made regarding what can and should be monitored. At local level, data collection is difficult and costly, particularly for agricultural support services and local institutions. Tracking efforts should therefore build upon existing mechanisms and processes.

2.4 Frameworks and methodologies for tracking adaptation

Although there exist various frameworks to monitor and evaluate adaptation actions (see Table 1 and Annex 2), they rarely apply specifically to crop or livestock farming, forestry, fisheries or aquaculture. Some of the existing frameworks have emerged in the context of climate funds, including the Adaptation Fund, the Pilot Programme on Climate Resilience (PPCR) and the Least Developed Country Fund (LDCF) of the Global Environment Facility (GEF). Others are developed by various international and national organizations, to monitor their programmes and projects.

The frameworks, tools and methods are generally developed for specific purposes; some focus on monitoring adaptation processes, while others cover both the monitoring and the evaluation of adaptation outcomes. A few recently developed frameworks are aimed at monitoring broad national level policy and planning processes, with little or no focus on outcomes. Meanwhile, some tools focusing on adaptation outcomes are mainly tuned to assess specific adaptation interventions at project level. The number of frameworks and tools covering both adaptation processes and outcomes is limited.

TABLE 1

SELECTED FRAMEWORKS, TOOLS AND METHODS TO MONITOR ADAPTATION PROCESSES AND OUTCOMES

Framework/tool/method	Target of monitoring and evaluation (process/outcomes)	Level of application	Sector and targeted users
Monitoring and reporting toolkit of PPCR (CIF, 2015)	Processes related to adaptation planning and mainstreaming	National and programme and/or project level	Multisectoral; national policy makers
Stocktaking for national adaptation planning (SNAP) tool (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2014)	Self-assessment of capacities to undertake NAP processes	National	Multisectoral; stakeholders involved in NAP processes
Framework for the assessment of skills for national adaptation planning (Mackay *et al.*, 2015)	Assessment of capacities to design NAP processes	National	Multisectoral; stakeholders involved in NAP processes
Tool for monitoring progress, effectiveness, and gaps (PEG) under NAP processes (UNFCC, 2015b)	Assessment of the essential functions of NAP processes	National	Multisectoral; stakeholders involved in NAP processes
The Vulnerability Sourcebook (Fritzsche *et al.*, 2014)	Changes in outcomes, with a specific focus on vulnerability	National and subnational	Multisectoral; adaptation practitioners
Impact evaluation guidebook for climate change adaptation projects (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2015)	Assessment of adaptation interventions contributing to a given outcome	National	Multisectoral; adaptation practitioners
Adaptation monitoring and assessment tool (AMAT) (GEF, 2012)	Assessment of project-specific processes, outputs and outcomes	Programme and/or project	Multisectoral; GEF projects' executing partners
Tracking adaptation and measuring development (TAMD) approach (Brooks *et al.*, 2011)	Monitoring of climate risk management processes and outcomes	National and local	Multisectoral; adaptation practitioners
Framework on making adaptation count (Spearman and McGray, 2011)	Monitoring and evaluation of adaptation processes and outcomes	National and local	Multisectoral; adaptation practitioners
Self-evaluation and holistic assessment of climate resilience of farmers and pastoralists (SHARP) (FAO, 2015)	Farmer's self-evaluation to assess resilience	Programmes and projects (household/community)	Agriculture (farmers and pastoralists)
Index for risk management (INFORM) (De Groeve *et al.*, 2015)	Assessment of country resilience and ranking	National	Multisectoral; national decision makers; international organizations
Resilience index measurement and analysis (RIMA) (FAO, 2016a)	Assessment of households' reactions to shocks and stressors	Household	Agriculture, with a focus on households
Participatory monitoring, evaluation, reflection and learning (PMERL) for community-based adaptation (CARE International, 2014)	Participatory monitoring, evaluation, reflection and learning to help design and implement community-based adaptation	Community	Multisectoral; focusing on community level interventions

The review of existing frameworks, tools and methods highlights the need to build a conceptual framework and methodology to uniformly track the different dimensions of adaptation (reducing vulnerability, strengthening adaptive capacity and enhancing resilience) in agriculture, in the short, medium and longer term.

The adaptation tracking framework should:

- consider the enabling environment created by institutions and policies;
- comprise assessments at both the national and the local level;
- broaden its focus from the means to achieve specific outcomes to the desired main outcome itself, that is decreasing countries' vulnerability and enhancing their resilience;
- prescribe repeated monitoring, in order to effectively contribute to informed policymaking and planning at the national level;
- produce outputs that may be disseminated to the wider community of adaptation planners and practitioners;
- be flexible enough to be tailored to country- and (sub)sector-specific circumstances;
- promote the participation in adaptation efforts of a range of stakeholders, including governments, regional organizations, development banks, bilateral technical cooperation agencies, non-governmental organizations, research institutions, civil society and the private sector.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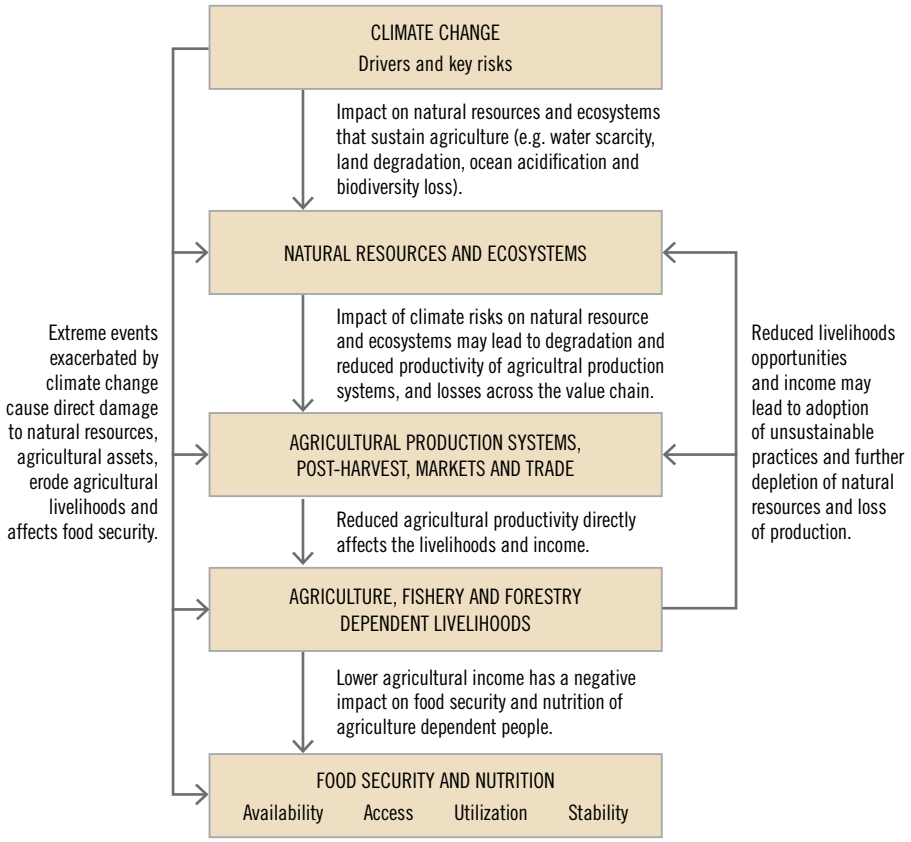
3. Framework for tracking adaptation in agricultural sectors

3.1 Theoretical basis
vulnerability and adaptation

Climate change directly affects natural resources and ecosystems and thus agricultural productivity. Impacts on agriculture have economic and social consequences, and affect food security in all four of its dimensions: food accessibility, food availability, food utilization and food systems' stability (Figure 2). Climate change impacts are transmitted through different pathways. At each stage, the severity of the impact is determined by climate drivers and risks, and by the vulnerability of the system (FAO, 2016b).

The severity of the impacts of climate change on food security and nutrition depends on the degree of vulnerability of the affected agricultural system. A key way to moderate, reduce and/or avoid these impacts is therefore to reduce a system's underlying vulnerabilities, strengthen its adaptive capacity and increase its resilience (FAO, 2016c). Resilience can be described as the capacity of systems, communities, households or individuals to prevent, moderate or cope with risk, and recover from shocks. A system is resilient when it is less vulnerable to risks across time, and can recover from them in a timely manner.

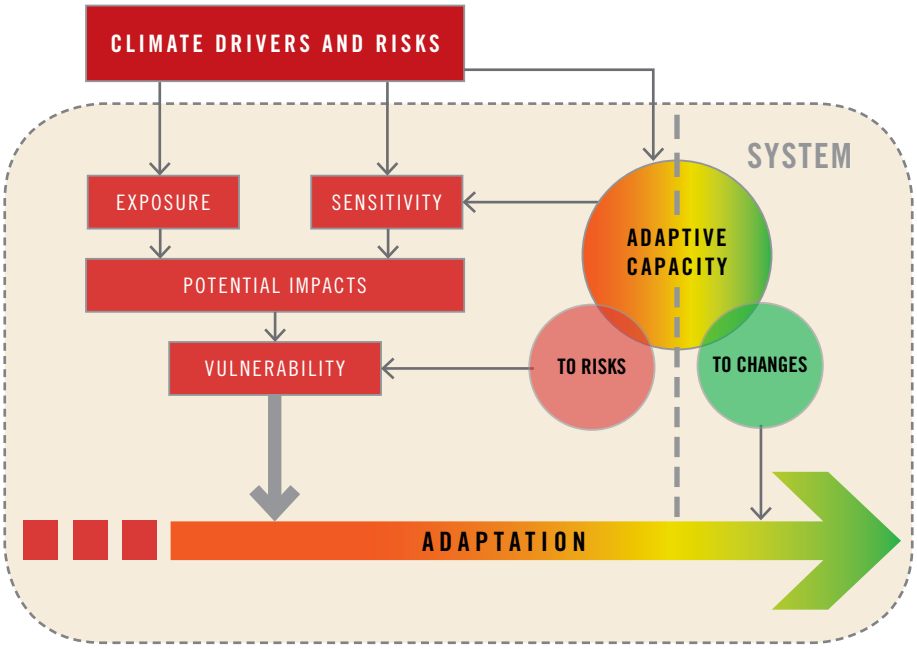
FIGURE 2. CLIMATE CHANGE IMPACT PATHWAYS IN AGRICULTURE: FROM CLIMATE CHANGE TO FOOD SECURITY



There are large differences between men and women in terms of impacts, vulnerabilities, responses and capacity to adapt to climate change across food systems. There is now a clear consensus that adaptation efforts should have explicit gender-based measures to ensure increased agricultural productivity, improved food and nutrition security, reduced poverty and enhanced climate resilience of households and communities.

Adaptation actions aim to moderate or prevent the impacts of climate drivers and risks by reducing the vulnerability, reinforcing the adaptive capacity, and enhancing the resilience of production systems and communities to climatic variability or change. Adaptive capacity encompasses two dimensions: the capacity to manage or moderate climate risks (including extreme climatic events), and the capacity to gradually respond to longer-term climate changes. As such, adaptation actions may be devised in response to sudden climatic extremes, or have a longer-term outlook. The two dimensions play an essential role, as they ensure a system's progress towards adaptation (Figure 3).

FIGURE 3. SCHEMATIC REPRESENTATION OF THE ADAPTATION PROGRESS, CONDITIONED BY EXPOSURE, SENSITIVITY, VULNERABILITY AND ADAPTIVE CAPACITY



Modified based on FAO, 2016a; Fritzsche *et al.*, 2014

The potential impact of climate change upon a system is determined by the degree of the system's exposure and vulnerability to climate change; the vulnerability of a system in turn depends on its adaptive capacity. A system's degree of exposure is determined by climate drivers and risks, and depends on the character, magnitude and timing of climate changes and variation. Meanwhile, the degree of sensitivity of a system determines to which extent a system is adversely or beneficially affected by a given climate change exposure (Fritzsche *et al.* , 2014). Together, exposure and sensitivity determine the potential impacts of climate variability and change. On the other hand, adaptive capacity refers to a system's ability to adjust to climate change and thus moderate potential damages, exploit opportunities, or cope with consequences. Key determinants of adaptive capacity include knowledge, technology, institutions, and economy.

Resilience focuses on the dynamic capacity of a system to recover from the impacts of climate changes, and adapt itself to its changing environment in the long term. Resilience refers not only to shocks (a change relative to an average), but also to the change of the average itself (FAO, 2016a). Increasing resilience to climate change can be achieved by reducing a system's vulnerability (exposure and sensitivity), and/or by increasing its adaptive capacity.

Adaptation actions can be implemented across domains (natural, productive, socio-economic, institutional and policymaking) and have a short- or longer-term outlook. Possible actions include physical risk reduction measures; crop and livestock improvement measures; adjustment of crop, livestock, fisheries and forestry management practices; economic diversification; and livelihood diversification. In addition, the adverse effects of climate change can be lessened by reducing the possibility for climate risks to be transmitted to agricultural systems and by enabling compensation to avoid cumulative and long-term effects (Gitz and Meybeck, 2012).

Social protection measures, in particular social assistance programmes that strengthen livelihood resilience and limit damages from shocks and stresses play a growing role in adaptation policies (Kuriakose *et al*., 2012). Evidence suggests that the development of social protection measures should go hand in hand with the reduction of communities' dependence on climate sensitive livelihood activities (Davies *et al*., 2009; Ziegler, 2016).

Actions to strengthen formal and informal institutions, formulate policies to improve livelihoods, raise awareness of climate change concerns and integrate them into development activities all contribute towards adaptation efforts.

3.2 Indicators for adaptation tracking

Adaptation indicators are used to monitor progress in the implementation of adaptation policies, strategies and actions, and measure their effectiveness. They must quantify, standardize and communicate, to policymakers and the public, complex and often disparate data and information.

Indicators can be used to monitor situations and trends, as well as measure progress towards one or more specific adaptation targets. Indicator-based tracking provides qualitative and quantitative information regarding the historical and current state of a system, and may reveal trends that provide an insight into present and future challenges and opportunities.

Adaptation indicators are useful to policymakers and development actors in various ways. Not only are they essential to monitor progress towards the implementation of adaptation policies, strategies and actions; they are also needed to:

- target, justify and monitor funding for adaptation programmes;
- communicate adaptation priorities to policymakers and stakeholders;

- compare adaptation achievements across sectors, regions and countries as appropriate; and
- provide inputs for international climate change related processes and mechanisms

Several indicators exist to monitor climate change adaptation. However, a single indicator or set of indicators is unlikely to be universally applicable (Harley *et al*., 2008; Spearman and McGray, 2011). Indeed, the diversity of adaptation processes and actions makes the selection of appropriate indicators complex (Brooks *et al*., 2011). Indicators must assess actions that are relevant to the stated objectives (César *et al*., 2013).

Adaptation indicators are fundamentally linked to development indicators due to the strong connections between adaptation and development actions and goals. For instance, a healthier population with high literacy rate, access to credit and social security is better equipped to adapt to the effects of a changing climate (World Bank, 2010). Therefore, the inclusion of standard indicators of development performance is necessary to track progress towards reduced vulnerability and enhanced adaptive capacity. In addition, tracking of adaptation progress should be complemented by the use of indicators specific to changing climate risks, their impacts and outcomes of adaptation actions (Brooks *et al*., 2011). Box 1 lists necessary characteristics of adaptation indicators.

BOX 1. NECESSARY CHARACTERISTICS OF ADAPTATION INDICATORS

Simple. Indicators should be simple, clear and easy to understand, as well as robust, transparent and objective. However, the oversimplification and standardization of indicators may cause a loss of valuable information.

Measurable. Indicators should be based on readily available data, or on data that can be made available at a reasonable cost. The data should be of high quality and up-to-date.

Analitically sound. Indicators should be analytically sound; their validity should be widely accepted. Indicators should enable comparisons across ecosystems, regions, communities and countries.

Relevant to policy. Indicator sets should be clearly relevant to policymaking. They should provide a balanced coverage of all key features of adaptation.

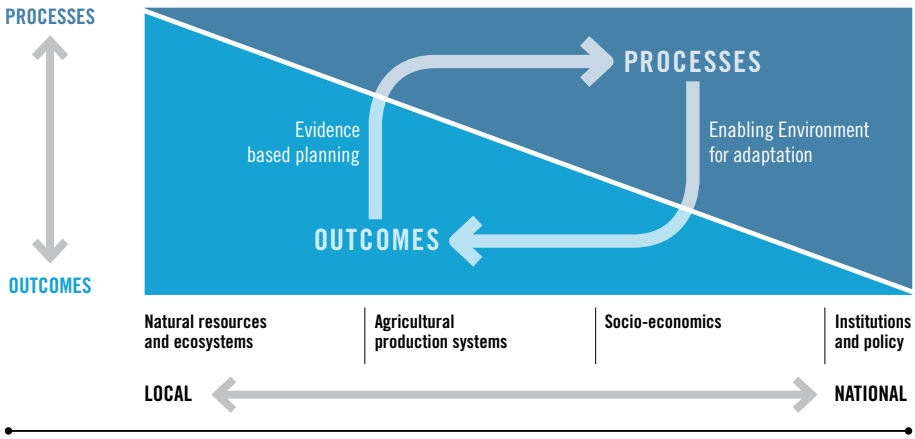
Transparent. The indicators should be transparent and easy to interpret, i.e. users should be able to assess the significance of the values associated with the indicators and their changes over time.

3.3 Linking theoretical bases and adaptation indicators

Tracking progress towards the achievement of short-, medium- and long-term climate change adaptation goals in agriculture is highly complex. The theoretical basis of indicators, the various elements of adaptation, and the spatial and temporal scales of tracking must be converted into an operational tracking framework, whereby the dynamic interplay between sectoral and cross-sectoral variables must be understood.

The total number of indicators used to track adaptation should be limited to curb the financial and organizational costs of monitoring; at the same time, however, a sufficiently wide range of indicators must be considered for tracking to be inclusive i.e. cover all aspects relevant to adaptation, including challenges, processes, impacts and outcomes of interventions, at various levels. Indeed, to promote inclusive, climate change resilient and sustainable development, tracking frameworks should include indicators related to natural resources and ecosystems, agricultural production systems, social and economic variables, and institutions and policymaking (see Figure 4).

FIGURE 4. THE BASIC FRAMEWORK FOR TRACKING ADAPTATION IN AGRICULTURE



Information regarding the outcome of adaptation actions at the local level is instrumental to the formulation of adaptation policies at the national level, while adaptation processes at the national level may contribute to the creation of an enabling environment for the implementation of adaptation actions at the local level.

The majority of the adaptation processes take place at the national level, but there are also some key processes facilitated by local institutions, which provide the enabling environment for effective implementation of adaptation actions.

Indicators concerning natural resources, ecosystems and agricultural production systems are largely outcome-based, and are mostly related to adaptation actions at the local level. Meanwhile, socio-economic indicators and indicators related to institutions and policymaking are largely process-based and concerned with the national level.

Natural resources and ecosystems. Indicators related to natural resources and ecosystems reflect the state of the environment and its interactions with agriculture; they provide information on the influence of natural resources and ecosystems on agricultural activities, as well as on the (potentially unintended) consequences of adaptation actions. The availability of fresh water resources in an ecosystem, for example, conditions the type of agricultural activities in that area, while (trend) data on water availability and quality provide indications as to the performance of the agricultural sector and its vulnerability to climate change.

Agricultural production systems. Adaptation in agriculture requires the sustainable management of resources to satisfy current and future needs. Indicators related to agricultural production aim to monitor the interaction between natural resources, ecosystems, agricultural production systems and climate change impacts. These indicators reflect the degree to which agricultural production systems are capable of producing desired outputs in a sustainable manner. For example, changes in the variability of cereal yields (percent variation from the baseline) help understand how agricultural production systems respond to climate change.

Socio-economic indicators. The facilitation of access to markets (for inputs and outputs, credit, insurance, etc.), information and basic services, as well as the promotion of livelihood opportunities and the provision of social protection (including social assistance and insurance) to agricultural populations (and especially to the most vulnerable groups) play an important role in efforts to reduce vulnerability to climate change. Socio-economic, gender-disaggregated indicators help understand the relationships between climate adaptation and socio-economic development. For example, the proportion of smallholders with access to microcredit schemes reflects the degree to which smallholders may invest in climate-resilient technologies and practices. Meanwhile, the tracking of food security indicators may provide insights into the degree of vulnerability to climate risks.

Institutions and policymaking. The capacities of institutions and the degree of coordination between institutional levels critically determine the effectiveness of climate change adaptation and climate risk management actions. Indicators related to institutions and policymaking reflect the degree to which institutions are capable of formulating and implementing effective adaptation policies and strategies for the agricultural sector. Policymaking for climate change adaptation should be well-informed, from the identification of priorities and policy options to the formulation, implementation and monitoring of actions. The integration of concerns related to climate change adaptation into policies for the crop and livestock farming, fisheries, aquaculture and forestry sectors helps create an enabling environment for adaptive capacity building.

TABLE 2

MAIN AND SUBCATEGORIES OF INDICATORS TO TRACK ADAPTATION IN AGRICULTURE

Main categories	Subcategories	
Natural resources and ecosystems	1	Availability of, and access to, quality water resources for agriculture
	2	Availability of, and access to, quality agricultural land and forests
	3	Status of ecosystems and their functioning
	4	Status of the diversity of genetic resources in agriculture
Agricultural production systems	1	Agricultural production and productivity
	2	Sustainable management of agricultural production systems
	3	Impact of extreme weather and climate events on agricultural production and livelihoods
	4	Projected impact of climate change on crops, livestock, fisheries, aquaculture and forestry
Socio-economics	1	Food security and nutrition (vulnerability)
	2	Access to basic services
	3	Access to credit, insurance, social protection in rural areas
	4	Agricultural value addition, incomes and livelihood diversification
Institutions and policy making	1	Institutional and technical support services
	2	Institutional capacity and stakeholder awareness
	3	Mainstreaming of climate change adaptation priorities in agricultural policies, and vice versa
	4	Financing for adaptation and risk management

Each of the four main categories of indicators comprises four subcategories, which are instrumental in disentangling the importance of the individual factors determining a system's vulnerability and adaptive capacity:

- The subcategories related to **natural resources and ecosystems** address the relationships between ecological systems, climate change stressors and agricultural production systems (e.g. water availability, land and forest resources, genetic diversity).

- The subcategories of indicators related to **agricultural production systems** focus on the sustainable management of agricultural resources, as well as on the current and future impacts of climate change on agriculture.
- The **socio-economic** indicator subcategories consist of socio-economic variables that determine vulnerability to climate risks. These include both indicators at the household level (e.g. gender-disaggregated indicators such as food security, access to basic services, credit and insurance, social protection and safety nets, income) and macroeconomic indicators (e.g. value added in agriculture).
- The subcategories of indicators related to **institutions and policymaking** indicate to which extent institutional arrangements are conducive towards the reduction of climate change vulnerability and the strengthening of adaptive capacity. They are mainly qualitative, process-based indicators (e.g. the quality of technical and institutional support services, institutional capacities, the level of stakeholder awareness, the degree to which climate change adaptation is mainstreamed into agricultural policymaking).

A distinction is made between quantitative and qualitative indicators, as well as between process and outcome indicators. Annex 3 presents an indicative list of possible indicators, including mostly indicators that are already being used as part of global monitoring efforts such as the Sustainable Development Goals (SDGs) or the Sendai Framework for Disaster Risk Reduction (SFDRR).

The choice of a set of individual indicators for each subcategory largely depends on the national context in which the tracking process takes place.

The levels of adaptation proposed for tracking indicators are illustrated in Figure 5, while corresponding descriptions are presented in Table 3.

A score between 0 (very low adaptation) and 10 (very high adaptation) is assigned to each of the (interrelated) four main categories of indicators in agricultural sectors.

The final score depends on a system's performance against a number of key indicators. The proposed tracking framework grants a large degree of flexibility to policymakers in the selection of indicators and enables the tailoring of rankings and scores to the objectives of specific policies or actions.

FIGURE 5. LEVELS OF ADAPTATION PROGRESS WITHIN AN AGRICULTURAL ADAPTATION-TRACKING FRAMEWORK

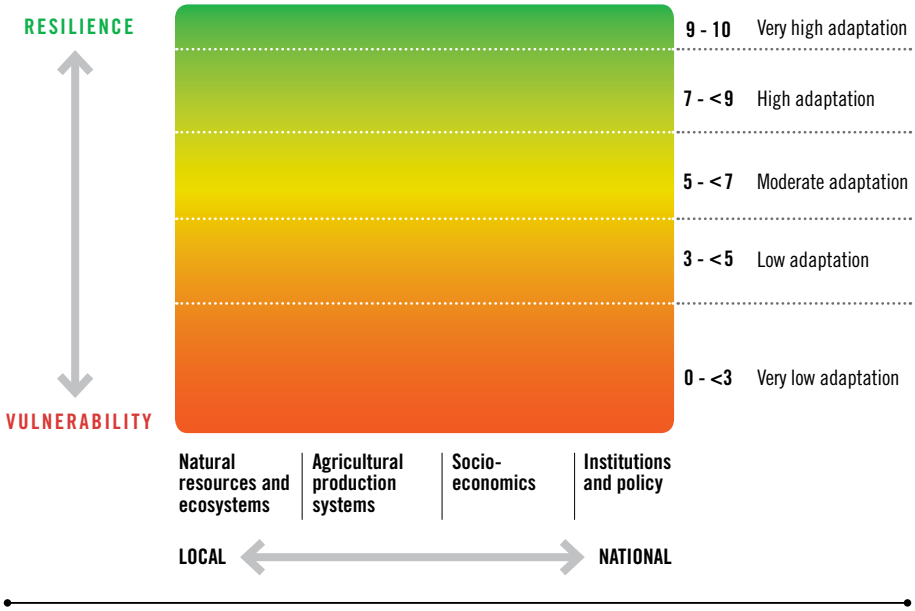


TABLE 3

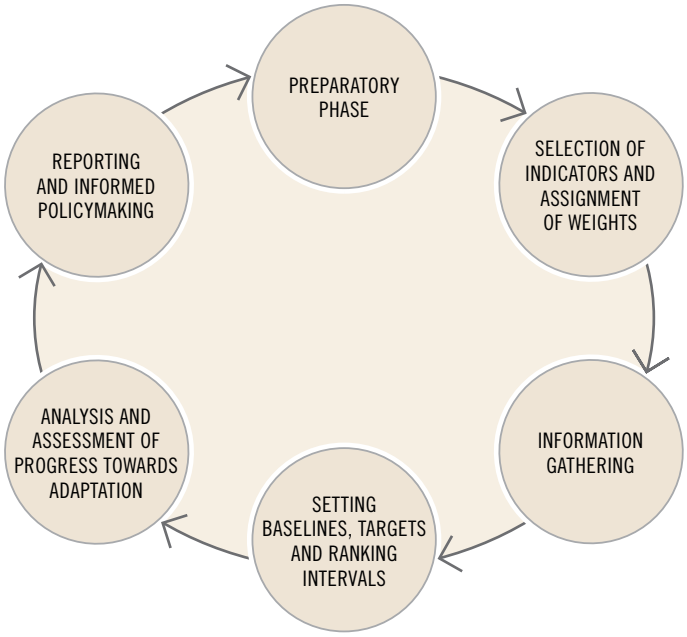
LEVELS OF ADAPTATION, CORRESPONDING SCORES AND INDICATIVE DESCRIPTION

Level of adaptations	Score	Description
Very low	**0 - <3**	These systems (broadly refers to natural resources, ecosystems, agriculture production systems, socio-economics of populations, institutions and policy) are frequently exposed and highly sensitive to climate change drivers and risks. A very high degree of exposure and sensitivity leads to extreme vulnerability to the impacts of climate variability and change. These systems show very low levels of adaptive capacity and resilience, and consistently fail or take a long time to recover, even after climate risks with a low intensity or magnitude. A multiplicity of vulnerability drivers and very limited adaptive capacities constrain these systems from achieving a higher level of adaptation.
Low	**3 - <5**	These systems are frequently exposed and highly sensitive to climate risks. Their vulnerability to the impacts of climate variability and change is high. They are characterized by low levels of resilience: they may recover after climate risks with a low intensity or magnitude, but often lack resilience to high-intensity climate risks. These systems display a certain level of coping and adaptive capacity, and their adaptive responses can mitigate the impacts of low-intensity to moderate climate risks in the short run. They are, however, highly vulnerable to moderate to high-intensity climate risks.
Moderate	**5 - <7**	These systems are moderately exposed and sensitive to climate risks. They are vulnerable to climate risks, but are somewhat resilient due to an inherent coping and adaptive capacity. The impacts of climate change on these systems are significant, as adaptation actions at different levels are inadequate and uncoordinated. These systems possess a certain capacity to respond to impacts of a local scale; they require, however, external support to deal with large-scale or high-intensity risks.
High	**7 - <9**	These systems are less exposed and sensitive to climate risks. They are vulnerable to major climate risks, but the impacts of these risks are moderated by well-planned adaptation responses. Adaptation responses have a long-term perspective, and future risks are anticipated in adaptation plans. These systems possess high levels of adaptive capacity and resilience; climate change adaptation priorities are well integrated into overall agricultural development policies and programmes, and well resourced. However, uncertainty with regard to climatic and socio-economic projections may impair adaptation actions.
Very high	**9 - 10**	These systems are very robust and well protected against climate drivers and risks. Positive synergies across systems (the natural environment, agricultural production systems, socio-economic conditions and institutions and policymaking) result in a very high level of resilience to both short-term shocks and gradual changes in climate drivers and risks. The threshold at which risks turn into impacts on these systems is very high.

4. Methodology for tracking adaptation in agricultural sectors

The selection and use of indicators for Tracking Adaptation in Agricultural Sectors (TAAS) consists of six interrelated steps, as illustrated in Figures 6 and 7. The assessment of progress towards adaptation is a continuous process, and requires constant adaptation to changing conditions, goals and targets. At each stage of this continuous process, the results and lessons from preceding stages should be taken into careful consideration.

FIGURE 6. THE CONTINUOUS, STEP-BY-STEP PROCESS OF CLIMATE CHANGE ADAPTATION TRACKING



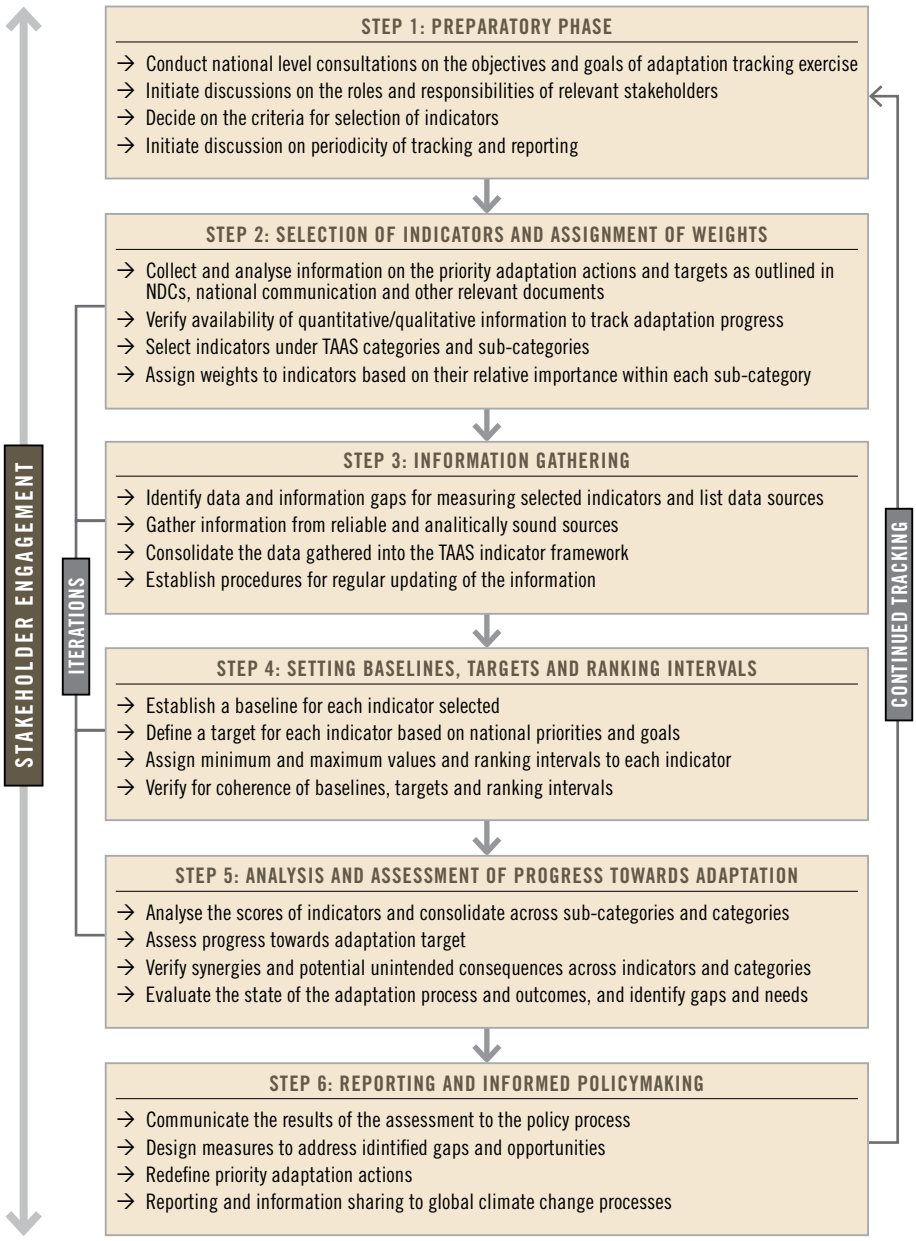
4.1 Preparatory phase

The preparatory phase of climate change adaptation tracking consists of initial consultations with stakeholders to build a consensus on the purpose and scope of the adaptation tracking process.

A number of questions need to be answered at the outset of the process, to ensure that tracking efforts are relevant to the specific context, such as:

- What must be tracked (adaptation process and/or adaptation outcomes)?
- What are the levels of application and aggregation (national/regional/local)?
- What is the purpose of the adaptation tracking system, and what is the intended use of its results (e.g. policymaking, reporting)?
- What are the criteria for the selection of tracking indicators?
- How does adaptation tracking fit within the broader policy and planning environment?
- What are the expected products of the tracking system?
- How will the required data and information be collected and synthesized?
- Which institutions and resources are available to provide the necessary support?
- Who are the stakeholders of the tracking process, and how they will be engaged?

FIGURE 7. THE STEP-BY-STEP PROCESS OF ADAPTATION TRACKING



Indicators should be selected through a multi-stakeholder consultative process, with input from key decision makers and adaptation practitioners in agricultural sectors. The selection process should take into account existing data sources by aligning the tracking framework with existing indicators such as those of the Sustainable Development Goals (SDGs) or the Sendai Framework for Disaster Risk Reduction (SFDRR).

4.2 Selection of indicators and assignment of weights

Adaptation is the result of multiple, simultaneous and interconnected actions across different sectors and domains, with varying spatial and temporal scales; thus, there exists no universally suited set of indicators to track adaptation. Decision makers should select tracking indicators based on the key problems, potential interventions and context-specific adaptation goals identified.

Targets and priorities relevant to agriculture as identified in nationally determined contributions (NDCs), national adaptation plans (NAPs) and similar tools with a focus on adaptation, can provide guidance for the selection of indicators. Box 2 proposes a number of criteria to choose indicators.

A balanced mix of indicators ensures that adaptation is accurately tracked at the national level. However, aggregated national indicators often hide the lack of adaptation of the most vulnerable ecosystems and communities. In such cases, a disaggregated analysis is needed.

The choice of indicators should be strictly linked to national planning processes, in particular to the NAPs, and aligned with key adaptation and sustainable development targets and goals in agriculture. Indicators may be selected based on the level of dependence on specific livelihood activities of vulnerable populations. For example, decision makers in least-developed countries (LDCs) may focus on indicators that track progress towards the reduction of socio-economic vulnerability to climate change impacts.

BOX 2. MAIN ISSUES TO BE CONSIDERED FOR CHOOSING INDICATORS

Process and outcomes. The selection of indicators should comprise both process- and outcome-based indicators (Harley *et al.*, 2008), to enable governments and policymakers to make the connection between adaptation policies at the national level and actions at local level (Mullan, *et al.*, 2013).

Adaptation at the local level. Adaptation tracking should accurately capture changes at the local level, since adaptation is first and foremost a local issue (Horrocks *et al.*, 2012). Vulnerability and adaptive capacity of most vulnerable populations, including indigenous communities and local communities should be captured.

Gender sensitivity. Tracking frameworks should include sex-disaggregated and gender sensitive indicators to monitor gender equality gaps and ensure adaptation efforts reach all groups (Stott, 2015) and better inform policy decisions.

Moving targets and baselines. Climate change adaptation goals are moving targets; baselines must be adapted accordingly. Indeed, in a context of climate change and evolving socio-ecological environments, baseline data change continuously, and no static baselines should be used.

Multifaceted nature of adaptation. Climate change adaptation is a multifaceted process; therefore, multiple indicators - including sector-specific (EEA, 2015) and institutional and governance related (Ellis, 2014) indicators should be used to track to adaptation.

Data availability. In many developing countries, the availability and quality of data is inadequate (UNFCCC, 2010). To counter this problem, existing data sets, developed for other purposes, may be used (EEA, 2015). Monitoring processes should be kept simple to avoid data overload (GDPRD *et al.*, 2008).

Bottom-up and top-down indicators. The use of bottom-up indicators (e.g. the vulnerability of agricultural systems) is crucial to ensure that tracking efforts consider the local context. The selection of indicators should capture existing local adaptation initiatives, and ensure that sufficient local data are collected (Kenya, Ministry of Environment and Mineral Resources, 2012). Equally, the indicators derived from top-down climate impact assessments using climate change data are also important.

Dynamic nature of vulnerability and adaptation. There exist multiple interpretations and definitions of vulnerability and adaptation. Their dynamic nature necessitates the constant updating of baselines, targets and ranking intervals (Fellman, 2012; Miller *et al.*, 2013; Brooks and Adger, 2004).

Institutions and policy dimensions. Indicators representing adaptation policies, programmes and projects that are implemented within a broader socio-economic and institutional context are to be considered. Policymakers must be able to attribute outcomes to policies, programme and projects, in order to judge the effectiveness of their interventions and improve future policymaking (Pokhrel *et al.*, 2015). Indicators on institutions and policy dimensions should also monitor the degree of participation to decision-making by different groups and social segments. Limited access to decision-making can constrain the adaptive capacity of disadvantaged groups.

In small island developing states (SIDS), indicators related to fisheries and aquaculture may be given central importance within the indicator subcategory of agricultural production and productivity, as may be indicators on the international coordination of adaptation efforts (e.g. across SIDS) within the subcategory of "institutional capacity and stakeholder awareness for adaptation and disaster risk management".

Adaptation progress in a landlocked, dry country with mainly rainfed agriculture and pastoralism may be tracked by prioritizing indicators related to the subcategories of "availability of and access to quality agricultural land and forests", "availability of and access to quality water resources for agricultural sectors", "food security and nutrition (vulnerability)", and "impact of extreme weather events on agricultural sectors and livelihoods", among others. In mountainous developing countries, priority may be given to the monitoring of the mountainous ecosystems on which agriculture and agroforestry rely, as well as to rainfall patterns and the impact of floods on agricultural production.

Once the indicators for each category and subcategory are selected, weights are assigned to them, to reflect the level of priority given. Importantly, the weighting should not produce composite indicators, which may blur the characteristics of individual indicators. Annex 3 proposes a weighting procedure. A key issue to be considered for selection of indicators is to ensure that the collection of data can be repeated over time, to enable comparability of results over a period.

4.3 Information gathering

After the identification of indicators, the data and information needed to assign a quantitative or qualitative value to the indicators must be collected. Data can be collected from a variety of sources, including international, national and subnational statistics, relevant reports, official documents, and interviews with key stakeholders. Importantly, data sources and computation methods should be reliable and analytically sound, and the process followed for gathering information should be communicated in a transparent way.

Annex 3 presents a number of possible sources of data on quantitative indicators. This list is not exhaustive, and additional sources may be used, both at the national and at the subnational level. Qualitative indicators are assigned an indicative statement describing the perceived performance of the indicator; the statement can be based on expert judgements, interviews and literature review.

4.4 Setting baselines, targets and ranking intervals

To track progress towards adaptation, baselines and targets should be established for the selected indicators. This task requires an in-depth understanding of the impacts of climate change on agriculture, and should involve extensive consultations with stakeholders at all levels. A baseline is the starting point against which the effectiveness of an intervention is monitored. The identification of baselines helps assess the status quo and address the underlying causes of a problem.

Once baselines are established, specific adaptation targets must be identified and agreed upon. Targets are the desired processes or outcomes related to the objectives of adaptation. Importantly, adaptation targets should consider the possible future evolution of indicators under climate change. Target setting is a crucial task for decision makers, as targets frame the specific steps that need to be taken to reach the stated goals. The definition of specific, measurable, analytical, realistic and time-bound targets is essential to effective adaptation tracking.

After the baselines and targets have been selected, the ranges of the values and the ranking intervals used to assign a final score to each indicator must be defined through consultations at the national level. The minimum value represents a very low level of adaptation; the maximum value a very high level of adaptation. Both baseline and target lie within this range. An indicator's score at a certain point in time reflects its level of adaptation.

The setting of ranking intervals depends on the type of indicator considered and is country-specific. Annex 3 provides some examples of ranking intervals for four different types of indicators. Separate guidelines on how to establish minimum and maximum values and ranking intervals for each selected indicator must be developed, taking account of the conceptual framework for, and methodology of, adaptation tracking.

4.5 Analysis and assessment of progress towards adaptation

After the selection of indicators, the setting of baselines, the definition of targets and the specification of ranking intervals, the tracking phase can start. During this phase, the status of each indicator at various points in time is assessed. Thus, progress towards adaptation from one point in time to another is gauged. The performance of all indicators should be analysed, as this enables the assessment of the relative performance of indicators. Information on the performance of an indicator or a category of indicators is conducive towards informed policymaking for climate change adaptation. Indeed, the outcomes of the tracking process are instrumental to the identification of those areas that require further adaptation-specific efforts.

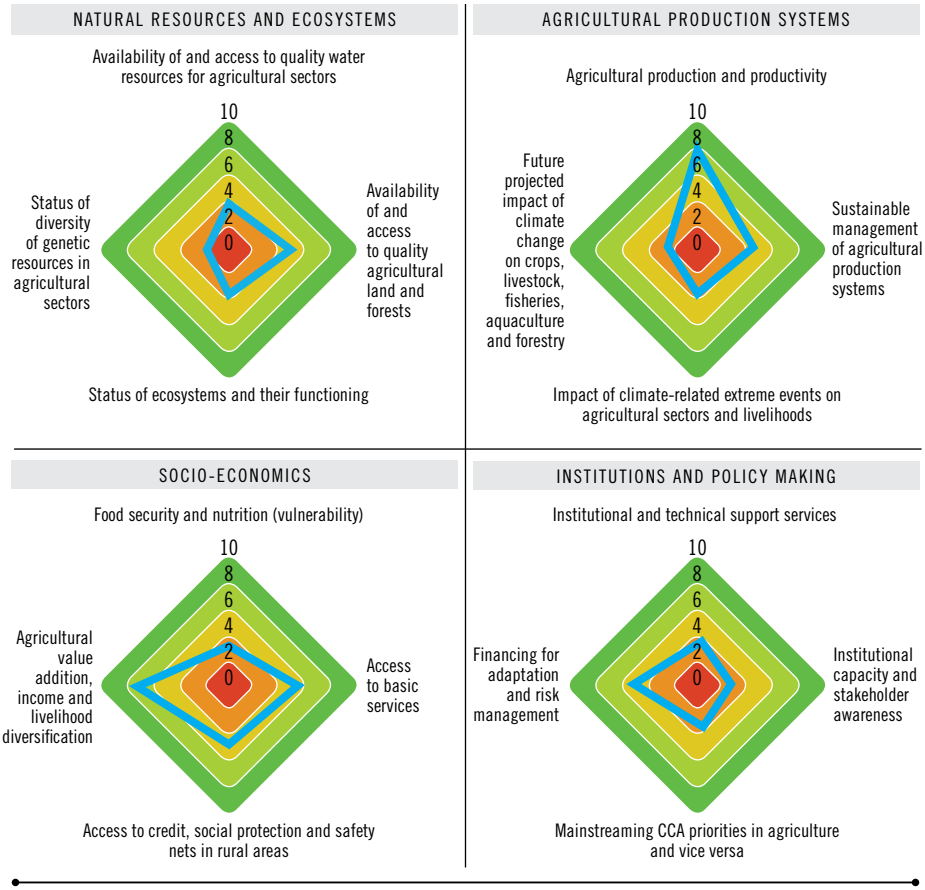
Progress towards adaptation (as a move towards the maximum values within a range) should be assessed by analysing individual indicators, as well as categories and subcategories of adaptation indicators. The analysis of categories or subcategories of indicators may blur the distinction between the performance of individual indicators; in such cases, the performance of individual indicators should be assessed separately.

The score of a subcategory is calculated as the average of the weighted scores of the indicators included in the subcategory. Figure 8 shows a hypothetical example of the scores for each subcategory; this overview enables the identification of the strengths and weaknesses of a specific subset of adaptation processes and actions. In this example, the major weaknesses of the system include: limited institutional capacities, a

low level of stakeholder awareness on climate change adaptation in agriculture, insufficient availability and quality of the natural resources and ecosystems sustaining agriculture, a strong impact of extreme weather events and even stronger projected climate change impacts on agriculture. Meanwhile, positive scores are attributed to indicators of agricultural production and productivity, agricultural value addition, incomes and livelihood diversification.

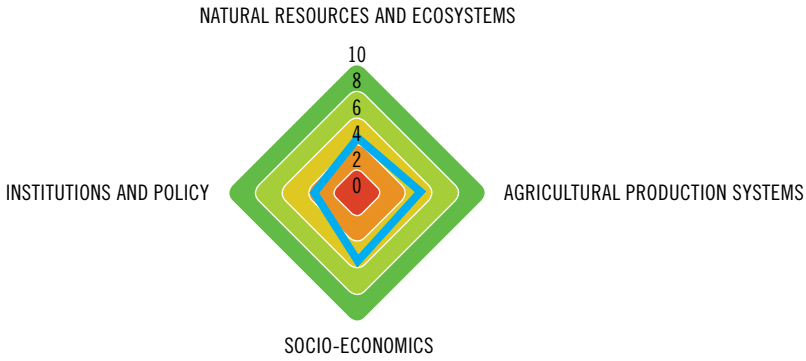
In certain cases, climate change impacts may have positive outcomes; such benefits are captured by indicators relevant to agricultural production and livelihoods.

FIGURE 8. HYPOTHETICAL EXAMPLE OF THE ASSESSMENT AND MAPPING OF THE PERFORMANCE OF SUBCATEGORIES OF INDICATORS



The score of an overall category of indicators is calculated as the average of the scores assigned to each of its subcategories. In the example shown in Figure 9, all four categories obtained a score between 3 (indicating a low level of adaptation) and 5 (moderate adaptation). The lowest scores were assigned to the dimensions of policymaking and institutions, indicating that this is where progress towards adaptation is hampered.

FIGURE 9. HYPOTHETICAL EXAMPLE OF THE ASSESSMENT AND MAPPING OF THE PERFORMANCE OF THE MAIN INDICATOR CATEGORIES



4.6 Reporting and informed policy making

The results of tracking processes allow decision makers to identify gaps in adaptation actions, single out unintended consequences or side effects of interventions, and devise alternative or compensatory measures to ensure that the desired adaptation goals and targets are achieved. Tracking progress towards adaptation is a continuous process in which the reporting and sharing of information are essential. At the end of the cycle, the tracking process starts again from the beginning, leading to the repeated assessment of indicators and the adjustment of targets and baselines.

Tracking adaptation in agriculture helps decision makers identify those policy areas that should be prioritized when budgets are allocated. Specific investments and actions should be defined based on an in-depth analysis of a system's social, financial, economic and environmental contexts.

4.7 An indicative example of tracking adaptation

Data from Kenya (Kenya, Ministry of Finance, 2012; Sina, 2012; Meyer, 2013) and expert judgement for qualitative indicators were used to analyse levels of socio-economic vulnerability to climate change at a national level in 2005 and 2009, and provide an illustrative example of adaptation tracking. The category of socio-economic indicators is divided into four subcategories representing those aspects of socio-economic development which are most relevant to climate change adaptation.

Background research on the country's socio-economic and climate change adaptation goals enabled the determination of the ranking intervals of quantitative indicators and the description of qualitative indicators. While this example only considers socio-economic indicators (for illustrative purposes), a comprehensive assessment should address all four main categories of indicators for adaptation tracking, to enable a proper understanding of the linkages between process and outcome indicators across different categories.

Tracking progress against socio-economic indicators of adaptation in agriculture requires a thorough understanding of the overall performance of each category of indicators included in the analysis. The specific conditions that determine the performance of indicators over time should be analysed within the broader context of sustainable development and poverty eradication.

Figures 10 and 11 summarize the results. These results are presented for illustrative purposes only; they should not be used to draw conclusions of any kind.

FIGURE 10. TRACKING SELECTED SOCIO-ECONOMIC INDICATORS RELEVANT TO CLIMATE CHANGE ADAPTATION – AN EXAMPLE FROM KENYA

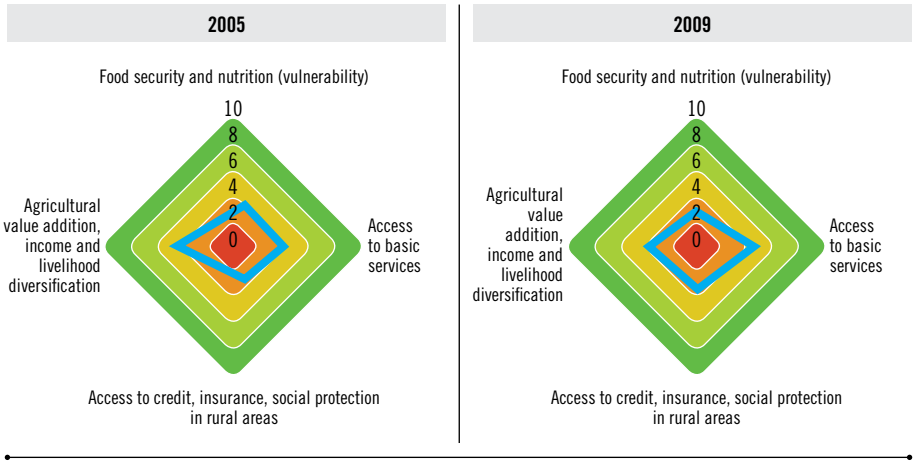
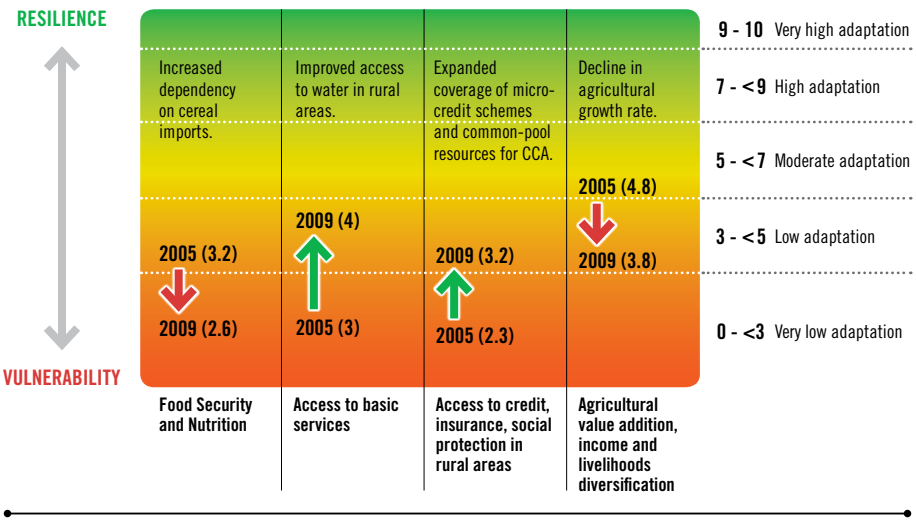


FIGURE 11. COMPARISON OF SELECTED SOCIO-ECONOMIC INDICATORS OF ADAPTATION IN KENYA BETWEEN 2005 AND 2009 – EXAMPLE



The results of this analysis show that the overall adaptation score on socio-economic indicators increased from 3.3 to 3.4 (on a scale from 0 to 10) between 2005 and 2009. The country remained at the "low adaptation" level. The figures above show that progress related to farmers' access to basic services, credit and social protection and safety nets was offset by a slack in agricultural output and a worsening of the food security situation.

Access to basic social services is an essential building block for development, and a prerequisite for effective adaptation to climate change in rural areas; a limited degree of access to basic services must be addressed if progress towards adaptation in agriculture is to be made. In this example, access to basic services in rural areas improved over the period under consideration; specifically, an increased share of the rural population gained access to improved water resources and sanitation (World Bank, 2017). In addition, rural populations' access to credit, insurance, social protection and safety nets improved between 2005 and 2009. The government of Kenya is also working on making some social protection programs shock responsive to be able to expand in the face of shocks.

Climate risks were identified as a concern in the National Policy for the Sustainable Development of Arid and Semi-arid Lands of Kenya, and access to markets and financial and social services for nomadic pastoralists were promoted with a view to addressing the risks of droughts and floods (Kenya, Ministry of Finance, 2012). Furthermore, agricultural insurance systems, including climate risk insurance mechanisms, have gained importance since 2005 (Sina, 2012). International climate funds have increasingly contributed to the country's adaptation efforts; in 2009, for instance, the Kenya Adaptation to Climate Change in Arid and Semi-arid Lands project received funding from the Global Environment Facility, to assist the country in adapting to climate variability and change and thus protect rural livelihoods.

Agricultural microcredit providers have expanded their activities at the local level, which has made it easier for farmers to obtain microloans. In addition, branchless banking, including the mobile money transfer system introduced in 2007, has facilitated urban-to-rural remittances within families (Meyer, 2013).

Agricultural communities have improved networking and collaboration on adaptation, for example to develop soil and water conservation structures, sink boreholes, or protect springs (Bryan *et al.*, 2013). Together, these improvements have fostered progress towards climate change adaptation.

Certain food security indicators, on the other hand, deteriorated in 2009 as compared to 2005 (FAO, 2017a) mainly due to the increase in food prices in 2009, which affected access to food. An increase in the country's dependency on cereal imports, combined with soaring prices, weakened food security, thereby increasing the agricultural population's vulnerability to climate risks.

The series of droughts that ravaged the country between 2008 and 2011 had a strong negative impact on agricultural production, causing a slump not only in crop production, but also in food processing (particularly grain milling and coffee and tea processing). Agricultural output fell by five percent in 2008 and 2.3 percent in 2009 (Kenya, Ministry of Finance, 2012).

4.8 Comparisons across regions and countries

The primary objective of the framework proposed in this study is to track adaptation progress at the national level. The use of this framework is not recommended to compare adaptation progress in different countries. Indeed, baselines, targets, inputs, processes and expected outcomes are highly country-specific. Countries differ in their level of vulnerability and adaptation to climate change; they have different resources, technical and institutional capacities, policymaking processes and political commitments.

For research purposes, the conceptual framework and methodology presented in this paper can be used to compare countries or regions, if identical sets of indicators and weights are chosen. Such comparisons would help rank countries and regions according to their status of vulnerability and adaptation to climate change, based on a unique and limited set of generally accepted indicators. The use of qualitative indicators to compare countries or regions requires expert judgement. Indeed, most process-based indicators (e.g. the level of coordination between institutions) are qualitative and context-specific in nature, and their valuation varies between countries. For quantitative comparisons of vulnerability or adaptation, the use of outcome indicators (such as the incidence of malnourishment in rural populations) is recommended. Here, it might be feasible to compound indices drawn from a small set of indicators across all four main categories.

5. Conclusions

Adaptation tracking refers to the monitoring of processes and outcomes of adaptation actions at national level. It shows a system's progress towards vulnerability reduction, adaptive capacity enhancement and mainstreaming of adaptation priorities into agricultural policies and plans. The framework and methodology for Tracking Adaptation in Agricultural Sectors (TAAS) outlined in this document helps to understand how multiple interventions contribute to climate change adaptation and resilience building.

Although the tracking framework and methodology are designed to track adaptation at the national level, users may adopt the methodology at multiple scales, from national to local. The choice of indicators can vary depending on the scales, reporting needs and data availability. Thus, the list of indicators in this paper is by no means exhaustive, and additional indicators may be used, depending on the objectives of the tracking exercise.

It is generally advisable to track indicators belonging to all major categories and subcategories elaborated in this paper. Nevertheless, a selected subset of indicators may be used in specific cases. Subsets of indicators can be grouped to represent processes, outcomes, agricultural sub-sectors (crops, livestock, fisheries, aquaculture and forestry) and national or local level adaptation priorities. Many of the proposed indicators are already being monitored at the national level; for others, monitoring is planned. However, additional efforts and guidance are needed to define baselines, targets and thresholds for tracking adaptation through participatory processes involving multiple stakeholders at both the national and the local level.

In summary, adaptation tracking at the national level is complex, but feasible.

To tackle this complexity, a conceptual framework and analytical methodology are proposed in this paper and, in a later phase, subjected to development of specific guidelines for implementation.

The frameworks and methodologies can contribute to the Paris Agreement's transparency framework that aims to bring all countries into a common process for providing improved data and track progress towards national adaptation targets in agricultural sectors.

Challenges related to data gaps, technical capacities, and the definition of roles and responsibilities at institutional and operational levels must be addressed to ensure the institutionalization of tracking processes at country level.

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Annexes

Annex 1. Glossary

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).

Adaptive capacity: The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, and to take advantage of opportunities or cope with the consequences (IPCC, 2014).

Coping capacity: The ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term (IPCC, 2014).

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, resources and infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected (IPCC, 2014).

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (FAO, 2013 as provided by UNISDR).

Indicator: Data element that represents statistical data for a specified time, place and other characteristics (UNECE, 2000).

Maladaptation: Adaptation actions that may lead to an increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future (IPCC, 2014)

Monitoring: The systematic tracking of the state of an initiative at any given time in terms of activities, inputs, outputs, targets and outcomes. It can also be used to describe the tracking of trends.

Outcome indicator: An indicator that measures the quantity of goods produced and services provided, as well as the efficiency of production and services (Horsch, 1997).

Process indicator: An indicator that measures ways in which services and goods are provided (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2013).

Resilience: For FAO, "resilience to shocks" is the ability to prevent and mitigate disasters and crises as well as to anticipate, absorb, accommodate or recover and adapt from them in a timely, efficient and sustainable manner. This includes protecting, restoring and improving livelihoods systems in the face of threats that impact agriculture, food and nutrition (and related public health) (FAO, 2013). For IPCC, 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, 2014).

Risk: The potential for consequences where something of value is at stake, and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as the probability of occurrence of hazardous events or trends, multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure and hazard (IPCC, 2014).

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC, 2014).

Social Protection: In terms of FAO engagement and support to countries, social protection comprises a set of policies and programmes that addresses economic, environmental and social vulnerabilities to food insecurity and poverty by protecting and promoting livelihoods (FAO, 2017b).

Stressors: Events and trends, often not climate-related, that have an important effect on the system exposed and can increase vulnerability to climate related risk (IPCC, 2014).

Tracking: In this report, tracking is referred to as a continuous process for the assessment of the status of a system in relation to adaptation i.e. the positioning of the system along the vulnerability-resilience continuum. Tracking encompasses monitoring and evaluation of adaptation processes and outcomes, and feeds back into the policy process.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2007).

Annex 2. A selection of existing frameworks, tools and methods to monitor adaptation processes and outcomes

The below list includes a number of frameworks, tools and methods developed to monitor adaptation processes and outcomes, both at the national (upstream policymaking and institutional level) and at the local level (outcomes of adaptation actions).

- The "Pilot Program for Climate Resilience" (PPCR) is a programme of the Strategic Climate Fund (SCF), which is one of the Climate Investment Funds (CIF). PPCR's monitoring and reporting framework includes 11 indicators. Five of these indicators are core indicators, measured and tracked across all PPCR pilot countries at the level of the investment plan (programmatic level). These core indicators enable the assessment of a country's progress in integrating adaptation considerations into development planning (including both the degree of integration of climate change considerations into national and sector specific plans, and evidence of strengthened governmental capacity and coordination mechanisms to mainstream climate resilience). The remaining six indicators are optional, and monitor progress at the project or programme level; they are aggregated to provide an indication of the overall progress at the national level (CIF, 2015). Country- and project-specific indicators are used depending on specific needs and requirements (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2013).

- GIZ has developed a tool for "Stocktaking for National Adaptation Planning" (SNAP) (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), 2014). This tool enables countries to assess their own capacities for national adaptation planning (NAP), based on seven crucial factors: availability and quality of climate-related information, human and institutional factors, long-term vision and mandate, implementation, mainstreaming, participation, and monitoring and evaluation. The main purpose of the tool is to improve groundwork activities for NAP. However, it can also be used to monitor adaptation progress and provide an indication of the status quo, target and progress related to each of the seven crucial factors at any point in time.

- The "Global Support Programme" is a framework to assess a country's capacity to design and implement NAP, and primarily aims to identify capacity gaps (Mackay *et al.*, 2015). This framework provides guidance on how to gather, organize and interpret data on institutional and individual capacities for adaptation planning. Although this information is primarily intended for NAP processes, it may also be useful when tracking capacity building.

- The Least Developed Countries Expert Group (LEG) of the United Nations Framework Convention on Climate Change (UNFCC) has developed a tool to monitor progress, effectiveness and gaps in NAP, to assess whether countries comply with a number of essential functions of the NAP process. The tool can be used to identify the expected outcomes of each function, as well determine which indicators may be used to evaluate progress (UNFCC, 2015).

- The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has issued the "Vulnerability Sourcebook" to provide a standardized approach and step-by-step guidance to conduct vulnerability assessments (Fritzsche *et al.*, 2014). Repeated vulnerability assessments are useful to assess changes in vulnerability and evaluate the effectiveness of processes or interventions in changing vulnerability-related outcomes. The organization's guidebook on impact evaluation of adaptation interventions (Deutsche Gesellschaft für Internationale Zusammenarbeit, 2015) may be used to assess the extent to which adaptation outcome(s) may be attributed to a particular adaptation policy, plan or intervention. Impact evaluations carried out according to the guidebook study how a situation would have developed if the intervention had not taken place (for example by comparing the beneficiaries of the intervention to a similar group that was not targeted by the intervention).

- The Global Environment Facility (GEF) has introduced a results-based management framework focusing on outcome- and output-indicators. The "Adaptation Monitoring and Assessment Tool" (AMAT) (Global Environment Facility, 2014) measures progress towards the achievement of outputs and outcomes at the portfolio and project level. It provides generic indicators for adaptation projects with a focus on reducing vulnerability, increasing adaptive capacity, promoting the use of technology for adaptation, and mainstreaming.

- The International Institute for Environment and Development (IIED) has developed a "Tracking Adaptation and Measuring Development" (TAMD) approach to measure adaptation along two interrelated tracks (Rai *et al.*, 2015). Track 1, entitled "Climate Risk Management" (CRM), focuses on monitoring processes, and concentrates on institutions, policies and capacities to manage climate risks. Track 2, "Adaptation Performance", focuses on outcomes and assesses whether CRM (as a process) is improving the adaptive capacities of a population, and thus human well-being. The TAMD framework includes indicators along both of these tracks, and stipulates the development of a theory of change to illustrate the relationship between them.

- The "Making Adaptation Count" framework (Spearman and McGray, 2011) provides a system to monitor and evaluate adaptation interventions based on a theory of change. The framework addresses both process and outcome monitoring, and can be applied at different levels. The Climate Change Commission of the Philippines has adopted and modified the framework to the country's national context, and used it to develop its national adaptation monitoring and evaluation system (Hammill *et al.*, 2014).

- The "Self-evaluation and Holistic Assessment of Climate Resilience of Farmers and Pastoralists" (SHARP) tool is an instrument to assess the climate resilience of smallholder farmers and pastoralists. It provides data to assist scientists and policymakers in their efforts to reduce the risks associated with climate change (FAO, 2015).

- The "Index for Risk Management" (INFORM) is a composite indicator which identifies countries at risk of a humanitarian crisis or disaster that would overwhelm their response capacity. INFORM is a joint effort of UN agencies, donors, NGOs and research institutions to establish a common evidence-based method for global humanitarian risk analysis (De Groeve *et al*., 2015).

- FAO has pioneered the development and the use of "Resilience Index Measurement and Analysis" (RIMA). RIMA is an innovative quantitative approach which explains why and how some households cope better with shocks and stressors than others. It enables comparison between different types of households in a country or area, and helps decision makers and other stakeholders to understand the dynamics of positive trends in resilience (and thus develop strategies that will yield positive results). Currently, FAO applies RIMA in more than ten countries in the Near East and sub-Saharan Africa, including Burkina Faso, Mali, Niger, Senegal, Somalia, South Sudan and Sudan (FAO, 2016a).

- "Participatory Monitoring, Evaluation, Reflection and Learning (PMERL) for Community-Based Adaptation (CBA)" (CARE International, 2014) is a guide aimed to promote participatory monitoring, evaluation, reflection and learning processes, in particular for shorter-term community-based adaptation projects and initiatives. The guide is targeted at project managers, field staff, communities and local partners engaged in designing and implementing community-based adaptation projects. The aims of the manual are to:

  - develop participatory strategies to help groups and organizations involved in community-based adaptation projects or action plans assess their effectiveness in achieving their objectives;
  - develop location-specific, community-based indicators to measure success in community-based adaptation;
  - monitor changes in local situations to inform community-based adaptation planning; and
  - show how findings from PMERL processes can be used to improve CBA project plans or wider community adaptation programmes. PMERL does not replace the monitoring and evaluation process that many project teams will need to follow to meet the requirements of donors or head offices (e.g. providing information about the extent to which project activities and outcomes are in line with a logical framework).

Annex 3. Types of indicators, respective ranking and weighting procedures

Quantitative indicators measured in percentage values

For this type of indicators, minimum and maximum values are predetermined, e.g. 0 percent is the worst performance and 100 percent is the best performance (or vice versa, if the scale is inversed). The baseline and target values fall in between 0 and 100 percent. The ranking intervals should be based on the adaptation targets and on the specific conditions of the country or area under analysis.

Example: The indicator "proportion of agricultural area under productive and sustainable agriculture" (proposed by FAO as an indicator to measure progress towards Sustainable Development Target Indicator 2.4[3]) is measured in percentage values, whereby 0 percent is the worst performance, and 100 percent is the best performance. Users may assign equal ranking intervals to this indicator, as indicated in Table 3a.

TABLE 3a.

EXAMPLE OF RANKING INTERVALS FOR THE INDICATOR "PROPORTION OF AGRICULTURAL AREA UNDER PRODUCTIVE AND SUSTAINABLE AGRICULTURE"

Level of adaptation	Score	Intervals (%)
Very low	0	0
	1	0.1
		10
	2	10.1
		20
	3	20.1
		30
Low	4	30.1
		40
	5	40.1
		50
Moderate	6	50.1
		60
	7	60.1
		70
High	8	70.1
		80
	9	80.1
		90
Very high	10	90.1
		100

3 "By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality" (see: FAO. 2017. Sustainable Food and Agriculture. [online]. Rome. [Cited 24 September 2017]. http://www.fao.org/sustainability/en/).

Quantitative indicators measured in absolute values

Here, users must assign minimum and maximum values to indicators. For some indicators, minimum and maximum values are common to all countries, while values for other indicators may differ based on the specific conditions of the area under analysis. Baseline and target values must fall in between the minimum and maximum values. Ranking intervals must be defined by users based on the adaptation targets and the specific conditions of the country or area under analysis.

Example: The indicator "water use efficiency in irrigated agriculture" measures the amount of crop produced per unit of water ($kg/ha^{-1}\ mm^{-1}$). The minimum and maximum values for this indicator should be determined on the basis of a number of key elements specific to the area under assessment (e.g. type of crops, average seasonal evapotranspiration). After assigning minimum and maximum values, users must identify a baseline and set a climate change adaptation target. The target value may be equal to or lower than the best value assigned to the indicator, depending on the context-specific policy relevance of the indicator. For example, decision makers may decide to assign ranking intervals as illustrated in Table 3b.

TABLE 3b.

EXAMPLE OF RANKING INTERVALS FOR THE INDICATOR "WATER USE EFFICIENCY IN IRRIGATED AGRICULTURE"

Level of adaptation	Score	Intervals ($kg/ha^{-1}\ mm^{-1}$)
Very low	0	<5
	1	5
		7.5
	2	7.51
		10
	3	10.1
		13.5
Low	4	13.51
		16
	5	16.1
		19.5
Moderate	6	19.51
		22.5
	7	22.51
		25
High	8	25.1
		27.5
	9	27.51
		30
Very high	10	>30

Qualitative indicators on a 0–10 scale

This type of qualitative indicator is valued according to 10 possible states, associated to qualitative statements. Maximum and minimum statements, as well as ranking intervals, are predetermined. Users must set qualitative baselines and target statements.

Example: The indicator "level of institutional capacity to assess and screen climate change adaptation measures", can be given statements from "none" (score: 0) to "best possible" (score: 10), as shown in table 3c.

TABLE 3c.

EXAMPLE OF RANKING INTERVALS FOR THE INDICATOR "LEVEL OF INSTITUTIONAL CAPACITY TO ASSESS AND SCREEN THE CLIMATE CHANGE ADAPTATION MEASURES"

Level of adaptation	Score	Statement
Very low	0	None
	1	Very poor
	2	Poor
Low	3	Very limited
	4	Limited
Moderate	5	Moderately low
	6	Moderate
High	7	Good
	8	Very good
Very high	9	Excellent
	10	Best possible

Qualitative indicators – Yes/No

This type of indicator can only be given two statements i.e. yes or no, without any intermediate statements. The "Yes" and "No" statements are given a score of 10 and 0 (or vice versa, depending on the indicator).

Example: The indicator "existence and operation of a national fund for climate change adaptation" may be assigned a Yes/No ranking, whereby No=0 and Yes=10.

Weighting of indicators

Once the indicators for each category and subcategory are selected, weights are assigned to reflect the relative importance of the indicators. The choice of the weighting system is a crucial step in the tracking process. It is an important element in the discussion of adaptation priorities and synergies between outcome- and process-indicators. As many stakeholders as possible should be involved in the weighting process.

Each indictor is given a weight between 0 and 1; the sum of the weights assigned to all indicators within the same subcategory should equal 1. The weight assigned to each indicator determines the influence of that indicator on the adaptation score of the respective subcategory. When there are no statistical or empirical reasons to differentiate weights, all indicators may be given the same weight.

Example: Table 3d provides an example of weighting for the subcategory **agricultural production and productivity** under the category **agricultural production systems**. Indicator weights are assigned to each indicator based on adaptation priorities and the country-specific context. In the example, high weights were given to **cereal yield variability change** and **change in herd size**, as crop and livestock production are priorities for the country. Meanwhile, indicators related to marine fisheries were given a weight of 0, as the country in the example is landlocked. It is important to note that the weighting procedure should not blur the identity of individual indicators by producing composite indicators, but rather be used as a tool to highlight the relative importance of the indicators within a subcategory.

TABLE 3d.
EXAMPLE OF WEIGHT ASSIGNING

Subcategory	Indicator	Indicator weight
Agricultural production and productivity	Proportion of agricultural land under irrigation	0.2
	Cereal yield variability change	0.2
	Change in herd size (specify type of animal)	0.3
	Average yield change in aquaculture	0.1
	Average annual fish catch change (marine fisheries) below threshold	0
	Fish stock productivity	0
	Annual change in round wood production below threshold	0.1

Annex 4. A list of indicators under each of the main and sub-categories of indicators (national level)

ANNEX 4a.

NATURAL RESOURCES AND ECOSYSTEMS CATEGORY AND ITS SUB-INDICATORS AND UNIT OF MEASUREMENTS AND INDICATIVE SOURCES OF DATA AVAILABILITY

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
1. Availability of and access to quality water resources for agriculture sectors	Level of water stress/freshwater withdrawal as a proportion of available freshwater resources	%	FAO/SDGs	Outcome	X	X	X	X	X	n/a
	Annual average precipitation/ Potential	Ratio	WDI/FAO	Outcome	X	X	X	X	X	n/a
	Proportion of bodies of water with good ambient water quality Evapotranspiration (P/PET) ratio	%	UNEP (GEMS/ WATER)/SDGs	Outcome	X	X	X	X	X	n/a
	Renewable internal freshwater resources per capita	m^3	FAO	Outcome	X	X	X	X	X	n/a
	Existence of functioning mechanism at local level to access adequate water resources for agriculture during scarcity/drought	Qualitative	New source	Process	X	X	X	X	X	n/a
2. Availability of and access to quality agricultural land and forests	Arable and forest land per capita of agricultural population	Ha	UNCCD/SDGs	Outcome	X	X			X	n/a
	Percentage of land that is degraded over total land area	%	FAO/UNE/ UNCCD	Outcome	X	X				n/a
	Proportion of agricultural population that owns arable land	%	FAOSTAT	Outcome	X	X				Y
	Existence of functioning mechanisms at the local level to ensure access to agricultural land, forests and fishery resources	Qualitative	New source	Process	X	X	X	X	X	n/a
	Percentage of people with ownership of secure rights over agricultural land (out of total agricultural population) by sex	%	FAO/SDGs	Outcome	X	X	X	X	X	Y
	Share of women among owners or rights bearers of agricultural land by type of tenure	%	FAO/SDGs	Outcome	X	X	X	X	X	Y
	Progress of countries in adopting and implementing a legal/ regulatory/institutional framework which recognizes and protects access rights for small scale fisheries	Qualitative	FAO/SDGs	Process			X	X		n/a

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
3. Status of ecosystems and their functioning	Forest area as a proportion of total land area	%	FAO/SDGs	Outcome					X	n/a
	Mountain green cover index	index	FAO/SDGs	Outcome					X	n/a
	Coverage by protected areas of important sites for forest biodiversity	%	IUCN/SDGs	Outcome					X	n/a
	Forest growth and productivity	–	FRA/NFMA	Outcome					X	n/a
	Dryland agricultural ecosystems (Percent to the total land area)	%	FAO	Outcome	X	X				n/a
	Proportion of exclusive economic zones managed using ecosystem-based approaches	%	UNEP/SDGs	Process			X	X		n/a
	Share of management plans designed and implemented based on EAF/EAA principles	%	New source	Process			X	X		n/a
4. Status of diversity of genetic resources in agriculture	Share of the top five dominant crop varieties in total crop production	%	OECD	Outcome	X					n/a
	Share of the three major livestock breeds in total livestock numbers	%	OECD	Outcome		X				n/a
	Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities	Number	FAO/SDGs	Outcome	X	X	X	X	X	n/a
	Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction	%	FAO/SDGs	Outcome		X				n/a
	Mechanisms in place for conservation of species diversity (crop/livestock/forest/fish) in-situ	Qualitative	New source	Process	X	X	X	X	X	n/a

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

ANNEX 4b.

AGRICULTURAL PRODUCTION SYSTEMS CATEGORY AND ITS SUB-INDICATORS AND UNIT OF MEASUREMENTS AND INDICATIVE SOURCES OF DATA AVAILABILITY

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
1. Agricultural production and productivity	Proportion of agricultural land under irrigation	% of total agricultural land	FAO	Outcome	X					n/a
	Cereal yield variability change	% from the baseline	FAO	Outcome	X					n/a
	Change in herd size (specify type of animal)	% annual change in number of heads	FAOSTAT	Outcome		X				n/a
	Average yield change in aquaculture	% change from the baseline	FISHSTAT	Outcome				X		n/a
	Average annual fish catch change (marine fisheries) below threshold	% change from the baseline	FISHSTAT	Outcome			X			n/a
	Fish stock productivity	Stock-recruitment relationship (steepness)	New source	Outcome			X			n/a
	Annual change in round wood production below threshold	% annual change	FAOSTAT	Outcome					X	n/a
2. Sustainable management of agricultural production systems	Proportion of agricultural area under productive and sustainable agriculture	% of agricultural area	FAO/SDGs	Outcome	X	X				n/a
	Progress towards sustainable forest management	% change	FAO/SDGs	Outcome					X	n/a
	Proportion of area under organic agriculture	% of agricultural area	FAOSTAT	Outcome	X	X				n/a
	Annual freshwater withdrawals in agriculture (below the maximum set threshold)	% of total freshwater withdrawals	WDI	Process	X	X				n/a
	Water use efficiency in irrigated agriculture	USD/m^3	FAO/SDGs	Outcome	X					Y
	Change in water use efficiency over time	%	FAO/SDGs	Outcome	X	X	X	X		n/a
	Conservation agriculture area: >30% ground cover	% of agricultural area	FAOSTAT	Outcome	X					n/a
	Degree of integrated water resources management implementation	0-100	UNEP/ SDGs	Process	X	X	X	X	X	n/a
	Fertilizer nutrient use efficiency on arable and permanent crops	Kg/kg/ha	FAOSTAT	Outcome	X					n/a
	Fishing effort	Total engine power per number of fishing days in a year (kilowatt days)	New Source	Outcome			X			n/a

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
3. Impact of extreme weather and climate events on agricultural production and livelihoods	Annual damage to agricultural assets and infrastructure	% of Agriculture GDP	FAO/ UNISDR/ SFDRR	Outcome	X	X	X	X	X	n/a
	Annual crop losses	% of Agriculture GDP	FAO/ UNISDR/ SFDRR	Outcome	X					n/a
	Annual livestock losses	% of Agriculture GDP	FAO/ UNISDR/ SFDRR	Outcome		X				n/a
	Annual fisheries and aquaculture losses	% of Agriculture GDP	FAO/ UNISDR/ SFDRR	Outcome			X	X		n/a
	Annual forestry losses	% of Agriculture GDP	FAO/ UNISDR/ SFDRR	Outcome					X	n/a
	Number/frequency of mass mortalities (e.g. diseases) due to environmental variables	% annual change from the baseline	New Source	Process			X	X		n/a
4. Projected impact of climate change on crops, livestock, fisheries, aquaculture and forestry	Projected water availability in 2050	% change from the baseline	National Communi-cation to UNFCCC; NAPAs; NAPs	Outcome	X	X	X	X	X	n/a
	Projected cereals production in 2050	% change from the baseline	FAO perspective studies	Outcome	X					n/a
	Projected livestock production in 2050	% change from the baseline	FAO/SDGs	Outcome		X				n/a
	Projected fisheries and aquaculture production in 2050	% change from the baseline	FAO/SDGs	Outcome			X	X		n/a
	Projected forest primary productivity in 2050	% change from the baseline	New source	Outcome					X	n/a

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

ANNEX 4c.

SOCIO-ECONOMICS CATEGORY AND ITS SUB-INDICATORS AND UNIT OF MEASUREMENTS AND INDICATIVE SOURCES OF DATA AVAILABILITY

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
1. Food security and nutrition (vulnerability)	Indicator of (food) price anomalies	Index	FAO/SDGs	Outcome	X	X	X	X	X	n/a
	Percentage of moderate/severe food insecurity in the population based on food insecurity experience scale	%	FAO/SDGs	Outcome	X	X	X	X	X	n/a
	Cereal import dependency ratio	%	FAO	Outcome	X					n/a
	Prevalence of undernourishment	%	FAO/SDGs	Outcome	X	X	X	X	X	n/a
	Percentage of children under 5 years of age who are underweight	%	FAO	Outcome	X	X	X	X	X	n/a
	Percentage of adults who are underweight	%	FAO	Outcome	X	X	X	X	X	n/a
	Proportion of rural population malnourished	%	FAO	Outcome	X	X	X	X	X	n/a
2. Access to basic services	Rural access to electricity	% of rural population	WDI	Outcome	X	X	X	X	X	Y
	Rural access to improved water source	% of rural population	WDI	Outcome	X	X	X	X	X	Y
	Literacy rate, adult (rural)	% of males aged 15 and above	WDI	Outcome	X	X	X	X	X	Y
3. Access to credit, insurance and social protection in rural areas	Percent of rural population covered under microcredit schemes	% of rural population	New Source	Outcome	X	X	X	X	X	Y
	Strength of common-pool resources (e.g. community seed banks)	Qualitative	New Source	Outcome	X	X	X	X	X	n/a
	Number of active community level institutions	Per 1000 people	New Source	Outcome	X	X	X	X	X	n/a
	Percent of agricultural population covered by climate risk insurance mechanisms	% of AG population	New Source	Outcome	X	X	X	X	X	Y
	Percent of agricultural population covered by safety nets	% of AG population	New Source	Outcome	X	X	X	X	X	Y
	Share of hazard affected population reached by social protection schemes	% of hazard affected population	New Source	Process	X	X	X	X	X	Y

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
4. Agricultural value addition, income and livelihood diversification	Agriculture, value added	annual % growth	WDI	Outcome	X	X	X	X	X	n/a
	Average income of small scale food producers (including non wood forest products) by sex and indigenous status	USD	FAO/SDG	Outcome	X	X	X	X	X	Y
	Percentage of rural labour force employed in agriculture	%	WDI	Outcome	X	X	X	X		Y
	Rural poverty gap at national poverty lines	%	WDI	Outcome	X	X	X	X	X	n/a
	Percent of rural population trained in value addition to agricultural production	%	New source	Outcome	X	X	X	X	X	Y
	Volume of production/labour unit by classes of family/pastorals/ forestry enterprise size	USD	WB/FAO/SDG		X	X	X	X	X	Y

ANNEX 4d.

INSTITUTIONS AND POLICY MAKING CATEGORY AND ITS SUB-INDICATORS AND UNIT OF MEASUREMENTS AND INDICATIVE SOURCES OF DATA AVAILABILITY

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
1. Institutional and technical support services	Percent rural population having access to early warning systems	% of rural population	New source	Outcome	X	X	X	X	X	Y
	Timeliness of early warning systems	Qualitative	New source	Process	X	X	X	X	X	n/a
	Number of gender-responsive awareness raising initiatives on climate change adaptation	Number/year	New source	Outcome	X	X	X	X	X	Y
	Proportion of agricultural population exposed to climate change awareness programmes	% of agricultural population	New source	Outcome	X	X	X	X	X	Y

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
2. Institutional capacity and stakeholder awareness	Level of knowledge of climate risks and vulnerabilities within the national and local institutions	Qualitative	New Source	Outcome	X	X	X	X	X	n/a
	Use of risk maps and data for adaptation planning	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Functioning of standard operating procedures for linking early warning systems to early actions	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Functioning of effective National Disaster Risk Reduction Platforms	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Functioning of a coordinating body/platform on climate change adaptation	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of coordination of climate change adaptation actions in agriculture at national level	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of coordination on climate change adaptation in agriculture at local level	% of AG population	New Source	Process	X	X	X	X	X	n/a
	Strength of public-private partnerships on climate change adaptation in agriculture	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of institutional capacity to assess and screen the climate change adaptation measures	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Proportion of national and local government officers received trainings on climate change adaptation over the last 5 years	% of total national and local government officers	New Source	Outcome						n/a
	Strength of local capacity building initiatives on climate change adaptation	Qualitative	New Source	Process						Y
	Number of initiatives to package good practices related to climate change adaptation	Number/year	New Source	Outcome						n/a
	Number of initiatives on lessons learning, knowledge management and exchange for climate change adaptation in agriculture	Number/year	New Source	Outcome						n/a

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
	Effectiveness of a multi-stakeholder platform addressing climate change adaptation	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of involvement of community-based organizations in implementing climate change adaptation actions	Number/year	New Source	Process	X	X	X	X	X	n/a
	Level of involvement of international organizations and research institutes in climate change adaptation	Number/year	New Source	Process	X	X	X	X	X	n/a
	Level of involvement of national research institutes in climate change adaptation	Number/year	New Source	Process	X	X	X	X	X	n/a
3. Mainstreaming of climate change adaptation priorities in agricultural policies, and vice versa	Level of use of climate forecasts for contingency planning to reduce impacts of extreme climate events	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of use of climate change impacts and scenarios in agricultural sectors for adaptation planning	%	New Source	Process	X	X	X	X	X	n/a
	Extent of use of climate information in crops, livestock, fisheries, aquaculture and forestry related policies and plans	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of integration of climate change adaptation priorities into crops, livestock, fisheries, aquaculture, and forestry policies, strategies and plans	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of integration of climate change adaptation into food security policies, strategies and plans	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Level of integration of agricultural sectoral priorities into climate change policies, strategies and plans	Qualitative	New Source	Process	X	X	X	X	X	n/a

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

Sub-Category	Indicator	Unit	Source	Outcome/ Process	Agricultural Subsectors*					Gender Disaggregated
					C	L	FI	AQ	FO	
4. Financing for adaptation and risk management	Proportion of Agricultural sector (Ministry of Agriculture/ Fishery/Forestry) budget allocated for climate change adaptation	% of total budget	New Source	Outcome	X	X	X	X	X	n/a
	Proportion of Environment sector (Ministry of Environment or equivalent) budget allocated for adaptation in agriculture	% of budget	New Source	Outcome	X	X	X	X	X	n/a
	Proportion of development budget (bi-lateral, multi-lateral) allocated to climate change adaptation in agricultural sectors	% of budget	New Source	Outcome	X	X	X	X	X	n/a
	Functioning of a national fund for climate change adaptation	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Levels of government budget allocated to climate resilience (social protection instruments, weather index based insurance etc.)	Qualitative	New Source	Outcome	X	X	X	X	X	n/a
	Level of support to climate change adaptation actions by an authoritative financial entity (e.g. Ministry of Finance)	Qualitative	New Source	Process	X	X	X	X	X	n/a
	Share of CC adaptation funds to the total budget for agriculture	%	New Source	Outcome	X	X	X	X	X	n/a
	Proportion of agricultural population who benefits from adaptation funds/financing (total)	% of AG population	New Source	Outcome	X	X	X	X	X	Y
	The agriculture orientation index for government expenditures	-	FAO/IMF/ SDGs	Outcome	X	X	X	X	X	n/a
	Total official flows (official development assistance and official flows) to the agriculture sector	$	OECD/FAO/ WTO	Outcome	X	X	X	X	X	n/a

* C = Crops; L = Livestock; FI = Fisheries; AQ = Aquaculture; FO = Forestry

Tracking adaptation in agricultural sectors

Climate change adaptation indicators

This publication provides a framework and methodology to track progress in adapting agricultural sectors to the impacts of climate change. Measuring progress in adaptation will help decision-makers to target resources most effectively and focus on the areas where meaningful progress can be made. The target audience includes national decision-makers, planners, development partners, research institutions and practitioners working on climate change adaptation.

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