Facilitating knowledge management for adaptation planning in Africa

Inventory of adaptation planning tools and frameworks

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Summary

Climate risks in Africa are increasing, threatening food systems and livelihoods, and making it imperative to identify locally appropriate adaptation strategies. This study was conducted under the project, 'Facilitating Knowledge Management for Adaptation Planning in Africa', which is funded by the Global Center on Adaptation (GCA). The project's goal is to enhance resilience of farming systems and livelihoods to climate change through wide-scale use of suitable adaptation planning tools. This study addressed the project's first objective of reviewing existing frameworks, tools, and methodologies, and assessing their potential and effectiveness for adaptation planning. The study produced an inventory of adaptation planning tools and frameworks. The identified tools and frameworks were classified into nine main categories: (1) adaptation tracking; (2) monitoring climatic shocks, forecasting and early warning, and dissemination of climate information services; (3) adaptation support; (4) modeling and simulation; (5) land use planning and conservation; (6) natural resource management; (7) knowledge exchange platforms; (8) climate-smart agriculture prioritization; and (9) climate risk and vulnerability assessment. This report presents a detailed description of each identified tool and provides a summary matrix of all the tools. Increasing awareness and knowledge exposure of national stakeholders to the identified and prioritized tools and frameworks would greatly help in building capacity for adaptation planning in Africa. Finding appropriate ways to link national stakeholders to these tools would ensure wide scale use while contributing to resilience building projects, programs, and policies.

1. Introduction

There is mounting evidence to suggest that anthropogenic climate change has led to more frequent and more intense climate extremes over land (Fischer and Knutti 2015; Magnan et al. 2021). Global surface temperature has increased by 0.99°C from 1850–1900 to the first two decades of the 21st century (2001–2020) and by 1.09°C from 1850–1900 to 2011–2020 (Arias et al. 2021). Global warming trends observed in recent decades are projected to continue over the 21st century and over most land regions at a rate higher than the global average. Mean precipitation changes have been observed all over Africa as well (Almazroui et al. 2020). Increases in the frequency and intensity of heavy rainfall have been observed in East and West Southern Africa. Parts of West Africa are projected to experience increased rainfall. In contrast, northeastern Africa, east southern Africa, and central Africa have experienced a decline in rainfall since about 1980. The Intergovernmental Panel on Climate Change (IPCC) fifth assessment (AR5) projects 'more frequent and longer heatwaves and warm spells in Africa' in addition to 'likely surface drying in southern Africa by the end of the 21st century' (IPCC 2014). Research also suggests that there is a strong spatial dependence of climate extremes which has led to frequently concurrent climate extremes in different parts of the world (Zhou et al. 2023).

Changing temperature and precipitation patterns associated with climate change are expected to disrupt food systems across the world through impacts on agricultural production, as well as on the health and socio-economic status of agricultural laborers and consumers (Bosello et al. 2006; McMichael et al. 2006; Dell et al. 2012; Myers et al. 2014; Nelson et al. 2014). Both the crop and livestock sectors are increasingly threatened by climate change (Rojas-Downing et al. 2017). Spatially concurrent climate extremes impose a great risk to the global food supply chain and amplify threats to global food security (Anderson et al. 2019; Gaupp et al. 2020; Tigchelaar et al. 2018).

The cost of not addressing climate change is already immense and will only get more expensive. Therefore, adaptation efforts are crucial (Shikuku et al. 2017). Different types of adaptation have been distinguished, including anticipatory versus reactive, autonomous versus planned, and incremental versus transformational adaptation (Smith 1997; Fisher et al. 2010; Mersha and van Laerhoven 2018; Vermeulen et al. 2013). Adaptation to climate change plays a key role in reducing climate-related risks along with mitigation and sustainable development. Identifying strategies and responses that are practical, sound and meet the actors' varied interests requires careful and flexible planning. Adaptation planning in human systems generally entails a process of iterative risk management. Effective responses to climate change require both the immediate relief from extreme events, as well as the development of longer-term plans that match the roles and capacities of actors with the appropriate scales and levels of the overall challenge.

Good collaboration among affected stakeholders is crucial for effective adaptation action. However, there is little information about suitable methods and frameworks for coordinating the actions of different actors and developing responses to climate change across multiple levels of time, space, and socio-political organization. In efforts to bridge this gap, a research team at the International Livestock Research Institute (ILRI) reviewed adaptation planning tools and frameworks with the potential for application in Africa. This report documents the identified tools and frameworks. The report has been produced as an output of the project funded by the Global Center on Adaptation titled, **'Facilitating Knowledge Management for Adaptation Planning in Africa**'.

2. Objective

The overall goal of the project is to enhance resilience of farming systems and livelihoods to climate change through wide-scale use of suitable adaptation planning tools. This study addresses the project's first objective: to review existing frameworks, tools, and methodologies, and assess their potential and effectiveness for adaptation planning.

3. Approach

Searches were conducted in English language peer-reviewed journals, grey literature such as institutional reports and briefs accessible on the internet, and organizational websites. We focused on articles, reports, and briefs that describe an adaptation planning tool, framework, or database. The titles and abstracts of these references were screened, and duplicate records were removed. A two-stage screening strategy was used to determine the relevance of articles returned from search strings to the research objective. In stage one, article abstracts and titles were screened. In stage two, the full texts for those abstracts meeting the initial inclusion criteria were downloaded and screened by the same eligibility criteria. In addition to the literature review, we consulted researchers and projects in the CGIAR.

4. Results

This section presents the results of the review. The section has two parts. The first part presents a detailed description of the tools. The second part provides a summary matrix of the tools. We categorize the identified tools and frameworks into six main groups namely, modelling, land use planning and conservation, adaptation tracking, dissemination of climate information services, natural resource management, knowledge platforms, and climate-smart agriculture (CSA) prioritization.

4.1 Detailed description of adaptation planning tools and frameworks

4.1.1 Tools and frameworks for modelling and simulation of climate change impacts

ClimateWizard

The ClimateWizard tool is a web-based simulator that was developed by the Nature Conservancy in collaboration with the University of Washington and the University of Southern Mississippi. Initially, the goal was to create a cutting-edge framework that could absorb new data from modeling agencies and rapidly get this knowledge into the hands of researchers. The addition of ArcGIS Server technology to the tool in December 2009 was a crucial step towards reaching this goal by enabling live web mapping services and maps to be queried on the fly and having better web application mashup capabilities. ClimateWizard also uses R-software to access time-series climate information and calculate outputs in tables, graphs, maps, and GIS data layers according to the user's needs.

ClimateWizard provides both expert and non-expert audiences with access to cutting-edge climate change research and the ability to see the effects everywhere on Earth. The new (Esri-powered) edition of this web-based tool allows the user to select a country and observe how climate has changed over time, as well as forecast what future changes are expected to occur in a specific area. ClimateWizard is the first application that compiles the whole spectrum of climatic history and implications for a landscape in a user-friendly style.

The forecasts generated depend on the three emission scenarios in the IPCC fourth assessment report. Users can choose the emission scenario they prefer. They can also choose from several General Circulation Models (GCM) that mimic the interaction of the atmosphere, land, oceans, and ice. The CimateWizard tool builds in 16 GCMs from different institutions, including the National Oceanographic and Atmospheric Administration Geophysical Fluids Dynamics Laboratory, the Max Planck Institute of Meteorology, and the Hardley Centre for Climate Prediction and Research. The web viewer allows users to choose an average of all the models, various in-between values, or single GCMs. Data can be seen through the web portal or imported into ArcGIS. The public can use the tool to understand the trends in climate change better, while technical users look for more specific information to inform planning and decision-making processes.

A few points are noteworthy. First, there is no single GCM estimate of future climate. A collection of projections (estimates) is generated by several GCMs under a variety of greenhouse gas (GHG) emission scenarios. Using an ensemble median (or mean) is a very effective means of improving the outcome of climate simulations that are often better than any individual future climate projection. Second, GCMs create comparatively rough spatial resolutions for ecological solutions. ClimateWizard can refine the spatial scales using high-resolution datasets from past observations.

Items required for the analysis using ClimateWizard include study area(s), specific time frame for trend analysis or two time periods for comparison in departure analysis, temporal domains like annual, monthly, or seasonal for summarizing data, variables of interest like temperature etc. After analysis, the tool stores the output in a way that is downloadable, and only internet access is required to peruse or download it.

The ClimateWizard tool can be used to analyse potential climate impacts, design adaptation strategies, and evaluate potential management and restoration activities. The users include land managers, policymakers, local authorities, planners, water utility managers, natural resource managers, engineers, scientists, and community members.

The Land Use Portfolio Modeler (LUPM)

The Land Use Portfolio Modeler (LUPM) was developed by the US Geological Survey as a risk-management tool for assessing plans and measures to minimize natural hazards. The LUPM combines geological and socio-economic data to predict the economic effects of strategies to reduce losses. It serves as a modeling, mapping, and communication tool to aid public agencies and communities comprehend and reduce their vulnerability and risk associated with natural disasters.

The model considers inputs such as the probability of a hazard event, the planning time frame, the assets at risk, the spatial probabilities of damage, the value and vulnerability of each asset, and the cost-effectiveness of potential risk-reduction measures. Through the LUPM, users can calculate estimations for the total cost, the number of mitigated locations, return on investment, expected loss, and community wealth preserved. Additionally, the tool allows users to generate maps illustrating the outcomes of each mitigation strategy and compare and prioritize policies based on their own preferences. Leveraging the spatial capabilities of a geographic information system (GIS), the LUPM offers an interactive mapping environment where users can create, analyse, visualize, and compare different scenarios for mitigating natural hazards.

The LUPM aids in minimizing the potential impact of natural disasters through the following means:

- Offering a modeling tool based on GIS technology, which enables the assessment of various strategies aimed at reducing risks associated with specific natural hazards.
- Utilizing data pertaining to a particular natural hazard event and the features susceptible to that event within the designated study area to determine the effectiveness of a particular mitigation approach. The features requiring mitigation are treated as investment portfolios and analysed using a combination of earth science and economic data. The user then evaluates the portfolios to determine the benefits of mitigating risks in a specific location. The decision makers will select a portfolio that represents a mitigation action with the highest expected return on investment while minimizing the associated uncertainty.

The LUPM tool has been used in several contexts, including regional land use planning, national park management, and private land conservation efforts. The tool was used to develop a conservation portfolio for the Northern Appalachian region of the United States, which included a suite of strategies for the resilience of the region's natural systems to climate change.

A wide range of users have embraced the LUPM tool for adaptation planning. The users include conservation organizations, government agencies, and private landowners. Its versatility and adaptability have made it a popular choice for those looking to incorporate climate change considerations into land use planning and management.

Comprehensive Livestock Environmental Assessment for Improved Nutrition, a Secured Environment, and Sustainable Development along Livestock and Fish Value Chains (CLEANED)

The Comprehensive Livestock Environment Assessment for improved Nutrition, a Secured Environment and Sustainable Development along Livestock and Fish Value Chains (CLEANED) is an online tool developed by the Alliance of Bioversity and the International Center for Tropical Agriculture (ABC) and the International Livestock Research Institute (ILRI). This tool enables users to swiftly assess the environmental effects of the growing livestock value chains by employing predictive techniques, making them investigate various impacts. While livestock keeping has proven to be rewarding, its production activities have a substantial impact on the environment and climate at large, affecting factors like soil and land, water, and biological diversity. The CLEANED tool provides users with the ability to evaluate these impacts and understand how they would be altered by introducing a new technology or changing the production model for livestock.

The tool simulates the effects of modifications in livestock production systems and value chains across multiple dimensions, including productivity, land use, water impacts, economics, greenhouse gas emissions, and soil health. It allows users to assess how these aspects would be influenced by various pathways of change. CLEANED is ideal for developing countries where obtaining relevant data for environmental assessment can be a challenge, as it is developed to utilize minimum data and it is user friendly and flexible, hence adaptable to the local systems.

This tool assists decision makers in comprehending the environmental consequences of intensifying livestock production and aids in the development of sustainable intensification plans. By evaluating the tool's results, decision makers can identify strategies to mitigate negative impacts while enhancing positive ones, thereby promoting environmentally sustainable livestock production. The target users include researchers, policymakers, scientists, project managers, and development managers.

Utilizing the CLEANED tool entails two primary steps:

1. Gathering and loading standard data, which includes information such as where the farm is located, inputs used in the farms, the seasons, the feed, and the production systems for livestock.

2. Analysing the data and producing reports that depict various scenarios of potential changes in livestock production systems. Users have two options: they can either perform calculations using the desktop interface by selecting the 'Run program' icon or proceed with calculations using R software. The output remains consistent regardless of the chosen pathway.

The outcomes generated by the tool can be scaled up to regional and national levels. This implies that the insights and findings obtained from the tool can be applied to larger geographical areas, allowing for a broader understanding of the environmental impacts of livestock production and value chains at a regional or national scale.

The tool's framework incorporates various environmental impact classifications and indicators, which include: 1) land and soil quality, which checks any changes in soil retention due to soil erosion, soil nutrients, and any alterations in the soil organic matter; 2) biological diversity, where any impacts to the environment are assessed through species richness index and any species that may be extremely vulnerable due to the growth of the value chain; and 3) the water quality and its availability, which is assessed by considering the total water requirement for feed production in relation to the total precipitation over the production area. Additionally, changes in water quality resulting from chemical use and manure management are considered. Finally, GHG emissions, in which three categories: enteric fermentation, which involves emissions from livestock digestion processes; from feed production, and from manure management, are evaluated based on guidelines provided by the IPCC.

NEAFWA (Northeast Association of Fish & Wildlife Agencies) Regional Vulnerability Modelling

The Northeast Association of Fish & Wildlife Agencies (NEAFWA) vulnerability model estimates how the vulnerabilities of important fish and wildlife habitats vary geographically across the northern eastern (NE) states of the United States (US), which are consequential geographical zones within which to make conservation designs and planning metrics.

The NEAFWA Regional Vulnerability Model's main objective is to help map geographical variations in habitat vulnerabilities across various NE states. The regional context of the model is to scale up so that the whole NE region develops regional adaptation strategies, develops a regional context that allows effective decision-making, and provides individual states with preliminary virtual assistance. It offers a combination of Excel-based formal modules and explicit elicitation. Target users include wildlife and fish conservation agencies, government agencies, and researchers.

The NEAFWA Regional Vulnerability Model has four linear modules:

Module 1 assesses the susceptibility of non-tidal wetlands/habitats to climate change considering 11 variables associated with sensitivity such as habitat's location in the overall geographical range, degree of adaptation to cold, reliance on specific hydrological conditions, sensitivity to extreme climatic events, intrinsic adaptive capacity, and vulnerability to maladaptive human responses. Module 1 can be used alone if the only objective is to identify the vulnerability to climate change.

Module 2 consists of five variables that evaluate the extent of the present and future habitats and their susceptibility not related to climate.

Module 3 combines the results of Modules 1 and 2 then assigns a vulnerability rank and confidence score to the degree the habitat is vulnerable to climate change, stressors unrelated to climate, and combination of climate and non-climate stressors.

Module 4 creates a story to explain the ranking assigned to each variable. Since ranking (scores) in the first three modules are based on expert opinion, the story provides a way to ensure transparency and evaluate consistency and underlying assumptions.

The model is guided by six major elements:

1. Assessment of vulnerability to climate change.
2. Assessment of vulnerability to non-climate stressors.
3. Interaction potential.
4. Assessment of overall future vulnerability.
5. Confidence evaluation (in all modules).
6. Narratives (transparency).

Since its finalization, the NEAFWA model has been adopted and used by individual states. It has successfully been used to evaluate habitat vulnerabilities in some states, including Maryland and New York. This proves that the model's framework and approaches are flexible enough to be applied in different landscapes.

Land Change Modeler (LCM)

Land Change Modeler (LCM) is a planning and decision support tool developed by Conservation International for rapid assessment and mapping of land change. Users of LCM can quickly assess land cover change, simulate future land change scenarios, and estimate species impacts. LCM can therefore be used to prioritize conservation and planning initiatives. It reduces the complexity of change analysis, resource management, and habitat evaluation to support decision-making and innovative land planning. LCM provides users with access to maps and assessments in one click hence it is very rapid.

One feature of the Land Change Modeler is that it incorporates special tools that assess Reducing Emissions from Deforestation and forest Degradation (REDD) mitigation strategies of climate change in addition to usual projection conditions. REDD in LCM accounts for all CO2 and non-CO2 baseline emissions.

Other vital features of the LCM tool include:

1. Maps and graphs are generated swiftly for the land change analysis, including gains and losses, net change, and the persistence of specific transitions, and using a change abstraction tool, underlying trends of complex land change are uncovered.

2. LCM models the possibility of land cover transformation. It expresses the likelihood that land will transition in the future using one of several methodologies, including logistic regression, Decision Forest Random Forest Implementation (DFRFI), Support Vector Machine, Weighted Normalized Likelihood, and SimWeight, a modified machine learning procedure.

Land change prediction. When modeling future possibilities, the modeler includes planning interventions, incentives, and restrictions e.g., reserve areas and infrastructure modifications that may modify how development proceeds. Scenario mapping is done by producing a continuous map of vulnerability to change or a hard prediction map based on a multi-objective land competition model with a single realization. Using a three-way cross-tabulation, LCM validates the quality of the projected land cover map in comparison to a real map. The number of hits, misses, and false alarms are all reported.

Sea Level Affecting Marshes Model (SLAMM)

The Sea Level Affecting Marshes Model (SLAMM) is an online tool managed by Warren Pinnacle Consulting, Inc, which allows users to view simulations of sea-level rise. The web-based application displays maps of pairs of the same area at different sea levels. SLAMM simulates dominant processes that involve wetland conversion and shoreline modification during long-term sea level rise. It predicts when and where marshes are likely to experience a change in inundation due to sea-level rise (SLR) based on SLR rates, elevation data, accretion/sedimentation rates, tidal data, and erosion rates. SLAMM also identifies locations that communities could migrate to in response to changes in water levels.

SLAMM utilizes the current coastal data such as tidal range, projected sea-level rise, and vegetation cover as well as the topography of the areas to simulate erosion of the marsh areas, inundation, and marsh migration. This helps predict the gain or loss of the marsh areas and assess the extent of impacts of sea-level rise on coastal wetlands over time. Using the SLAMM tool for simulation, users can determine the vulnerability of these specific coastal areas and aid decision makers in developing adaptation and mitigation strategies for conserving the salt marsh areas and the coastal ecosystem, together with the dependent community.

With SLAMM, users can:

- Simulate and visualize the impact of sea-level rise scenarios on salt marsh areas.
- Compare these impacts of multiple sea-level rise scenarios in different time frames and analyse the map results further.

The target users include scientists, coastal managers, and policymakers.

How it works

SLAMM uses digital elevation data, topography information, seal-level rise data, and tidal areas in a particular coastal area as a baseline for modeling and simulation. These datasets are used to calculate the submergence of the elevation levels in the marshes and to predict the migration of the marshes towards the landward areas depending on factors such as vegetation cover and topography.

The tool also calculates the possibility of conversion of the marshes to open waters, based on the elevation levels. It also evaluates species distribution and habitat loss, as part of the ecological impacts of the sea-level rise.

The SLAMM model incorporates ArcGIS, which enables users to view the outputs in a mapping environment. The output can be viewed in different dimensions such as 2D and 3D models. Before running the SLAMM model, the GIS software is used to convert all spatial data into raster format, ensuring that they have the same cell sizes and dimensions which helps in the standardization of the data for consistent results.

The Assessment of Impacts and Risks of Climate Change on Agriculture (AIRCCA) Model

The Assessment of Impacts and Risks of Climate Change on Agriculture (AIRCCA) model is a tool designed to evaluate the potential effects and risks of climate change on agricultural systems. It provides a framework for assessing the impacts of climate change on crop production, livestock, water resources, and overall agricultural productivity. The AIRCCA model takes into account various climatic variables, such as temperature, precipitation, and CO2 concentrations, and combines them with agricultural data to analyse the potential consequences of climate change on agricultural systems. It incorporates both biophysical and socio-economic factors to provide a comprehensive understanding of the impacts and risks associated with climate change in agriculture. The model allows policymakers, researchers, and stakeholders to simulate different scenarios and assess the vulnerability of agricultural systems to climate change. By considering various factors and incorporating feedback mechanisms, it helps in identifying adaptation strategies and developing appropriate policies to mitigate the negative impacts of climate change on agriculture.

The AIRCCA model is a valuable tool for decision makers to understand the potential risks and devise strategies to build resilience and enhance the adaptive capacity of agricultural systems in the face of climate change. It contributes to the development of sustainable and climate-smart agricultural practices, ensuring food security and promoting the resilience of farming communities.

Modelling System for Agricultural Impacts of Climate Change (MOSAICC)

The Food and Agriculture Organization of the United Nations (FAO) and European research institutes have collaborated to develop a comprehensive set of models for conducting national-level climate change impact assessments. This package, named FAO-MOSAICC (Modelling System for Agricultural Impacts of Climate Change), allows for sequential analysis of climate data downscaling, spatial interpolation, hydrological modeling, and crop and economic simulations. FAO-MOSAICC is specifically designed to be distributed to national institutions in developing countries. While it can be utilized for various analyses, such as examining the impacts of climate change on water resources and crop yields, its primary goal is to identify robust adaptation strategies to mitigate the potential adverse effects of climate change on national food security.

MOSAICC employs an interdisciplinary assessment approach to addressing climate change impacts and adaptation planning in the agriculture and food security sectors. It is developed within the framework of the EU/FAO ‘Improved

Global Governance for Hunger Reduction' program. It assesses crop production systems, water and forest resources and the national economy under changing climatic conditions.

Agricultural Model Intercomparison and Improvement Project (AgMIP)

Founded in 2010 by a group of US and international agricultural modelers, the Agricultural Model Intercomparison and Improvement Program (AgMIP) has grown to encompass a global community of scientists working to improve agricultural systems data and models and to advance their use to support decision-making from farm to national and global scales. More recently, AgMIP has begun mobilizing climate, agriculture, economics and trade, health and nutrition, security, and humanitarian aid expertise to advance next-generation tools and decision support systems to address current and future challenges to food systems that deliver reliable and nutritious foods. The AgMIP mission is to significantly improve agricultural models, and scientific and technological capabilities, for assessing impacts of climate variability and change and other driving forces on agriculture, food security, and poverty at local to global scales. Among the specific objectives of AgMIP are to:

1. Develop frameworks to identify and evaluate promising adaptation technologies and policies and to prioritize strategies.
2. Collaborate with regional experts in agronomy, soils, animal sciences, economics, and climate to build a strong basis for applied simulations addressing key climate-related questions.
3. Utilize multiple models, scenarios, locations, crops, and participants to explore uncertainty in climate and agricultural productivity and the effects of data and methodological choices.
4. Perform multi-model integrated regional and global assessments of technology and policy options for increasing food security and adapting to current and future climate risks.
5. Incorporate state-of-the-art climate, crop, and agricultural economic model improvements into coordinated regional and global assessments of current and future climate impacts.

Climate Adaptation in Rural Development (CARD) Assessment Tool

The Climate Adaptation in Rural Development – Assessment Tool (CARD) is a platform to explore the effects of climate change on the yield of major crops. It is intended to support the quantitative integration of climate-related risks in agricultural and rural development investments and strategies, including economic and financial analyses (EFA). This tool provides data for 17 major crops in all International Fund for Agricultural Development (IFAD) regions. CARD has been developed with funding from IFAD's Adaptation for Smallholder Agriculture Programme (ASAP2). The CARD tool was developed to provide simplified estimates of climate change-induced yield variability. Temperature and precipitation are essential input factors to crop growth, and with climate change increasingly disturbing their patterns, agricultural production is projected to be progressively affected. Due to its reliance on temperature and precipitation, particularly in rainfed agricultural systems, agriculture is often presented as the sector that is most vulnerable to climate change. The tool is built on the IPCC Representative Concentration Pathway RCP8.5 scenario, projecting the highest concentration in GHGs. Adding to this scenario, the tool uses global gridded crop-climate models that simulate the biophysical processes related to crop growth in order to capture the long-term effects of climate change.

The user guide for CARD Assessment Tool is accessible at https://www.ifad.org/en/web/knowledge/-/publication/climate-adaptation-in-rural-development-card-assessment-tool.

4.1.2 Tools and frameworks for land use planning and conservation

Framework for categorizing the relative vulnerability of threatened and endangered species

The National Centre for Environmental Assessment (NCEA)/Office of Research and Development in the US created an evaluative framework to help in classifying species' sensitivity to climate change. The framework provides information to the ecosystem and resource managers to support the decision-making process regarding management activities that account for the most species that are threatened/endangered and susceptible to climate change. The framework can also be useful in guiding management decisions for species that are not listed as endangered.

This framework has four modules. They take users through a systematic process for:

1. Classifying species baseline vulnerability to extinction or significant population decrease through scoring those elements of the species' life history, demographics, and conservation status that influence its chance of survival or extinction (excluding climatic changes).

2. Classifying the likely vulnerability of species to future climate change. This includes potential behavioural, demographic, habitat usage, psychological, and ecological responses to climatic changes.

3. Developing a matrix that gives an overall score of the vulnerability of species to non-climate and climate change stressors. Combines the results of the first two models into a matrix that maps into the following categories (1) least vulnerable, (2) less vulnerable, (3) highly vulnerable, and (4) critically vulnerable.

4. Determining uncertainty in quantitative estimation of species vulnerability (in terms of high, medium, or low), based on the evaluation of uncertainty performed in the first three modules.

The framework has been applied in assessing threatened and endangered species in the US.

Climate Change-Resilience and Adaptation Planning Tool (CC-RAPT)

The Climate Change-Resilience and Adaptation Planning Tool (CC-RAPT) is an online interface and a scoring tool developed by the Marine Subgroup of the International Union for Conservation of Nature (IUCN), the World Commission on Protected Areas (WCPA) and the Climate Change Specialist Group. The CC-RAPT tool aids in assessing the vulnerability of the marine environment, and the preparedness of the marine ecosystem in the face of the climate crisis. The tool is designed to help Effective Area-based Conservation Measures (OECMs) and Marine Protected Areas (MPAs) practitioners to understand the changing climate and how it relates to marine biodiversity conservation. Despite being able to operate independently, CC-RAPT can be used together with other climate change assessment tools such as the Climate Vulnerability Index.

The primary goals of the CC-RAPT tool are:

1. To assist Marine Protected Area managers and staff in evaluating and enhancing their climate resilience and adaptation efforts. By conducting an assessment using CC-RAPT, MPA programs can identify areas that need improvement in addressing climate change impacts on marine biodiversity and the associated cultural, social, and economic benefits.

2. To enable MPA managers and staff to gain insights into the effectiveness of their current management and governance strategies on climate change and prioritize their actions and allocate resources effectively.

3. To emphasize the importance of integrating climate change into ongoing MPA management efforts.

4. To provide access to a range of resources that can assist MPA programs in operationalizing the results of their assessments. These resources may include guidelines, best practices, case studies, and tools specific to climate resilience and adaptation in marine environments. By leveraging these resources, MPA managers and staff can further enhance their understanding and implementation of climate-informed strategies.

How it works

The CC-RAPT tool interface allows users to answer questions divided into categories including a scoring section, an explanation, ideas for improvement, and any resources and tools that can be useful to the whole marine community. The scoring section allows the user to give a score ranging from 1 to 5 (the level to which one agrees or disagrees with the statement or question presented). The user then provides an explanation of the score given to each question and suggests ideas for improvement depending on the gaps identified. Lastly, the user can provide reference resources, tools, or related examples. The MPA managers and all users, in general, are encouraged to answer according to their knowledge gained from experience, as this keeps the authenticity of the results. The tool is simplified and user-friendly, hence the users should be able to answer regardless of the quality of answers provided or their knowledge.

CC-RAPT provides MPA managers and staff with the opportunity to reflect on their management practices in the face of climate change. By engaging in self-reflection, MPA programs can identify gaps and areas for improvement. These findings can then prompt additional management interventions to address the identified gaps. The results provided can help managers in designing resilience and adaptive measures.

The tool is useful for Marine Protected Area managers, regulators, staff, implementation partners, local communities, and government organizations.

Northeast Climate Data

The Northeast Climate Data (NCD) is a web-based database produced as part of the Northeast Climate Impacts Assessment in a joint investigation by a Union of Concerned Scientists and independent scientists from the northeastern US and beyond. Managers and planners involved in land, water, wildlife, and cultural resources in the Northeast can obtain scientific knowledge, tools, and approaches for monitoring, predicting, and adapting to climate change from this database. Variables such as changes in temperature, relative humidity, precipitation, sunshine, wind, and snow cover for the US Northeast in different scenarios (such as in higher and lower emissions) are included in the projection of the climate data. The tool can be used by conservation managers and scientists.

The northeastern climate data sets are in easy-to-use formats, tailored to meet stakeholders' needs in evaluating and managing risks from climate change and variability. Output can be displayed geographically or as a time series and can be plotted for the entire region, an individual state, or major cities.

The database has model-derived variables like solar radiation and evapotranspiration (soil temperature), which are rarely observed and are included in spatial datasets. Missing observations in the dataset are replaced with estimated values to have a serially complete record.

With the availability of regional climatic data, stakeholders can collaborate on climate resilience planning, leveraging mechanisms such as land use planning, infrastructure protection needs, building rules, crisis preparedness and action, and resilience building to mitigate the increased vulnerability of residents in the Northeast caused by impacts of climate change.

Conservation Standards

The conservation community tackles large, complex, and urgent environmental problems. The stakes are high. We need to know how to use our resources most effectively to achieve lasting impact. The Conservation Standards—developed, tested, and continuously refined by conservation leaders across the world—provide a clear, systematic approach to managing, monitoring, planning, and learning from past conservation efforts. The standards promote the use of best practices, prioritization at various stages, testing of assumptions, and data sharing. They are supported by a lively community of Conservation Standards users actively developing, refining, and sharing practical guidance and innovations to help other teams effectively use the Conservation Standards to improve their work.

4.1.3 Tools and frameworks for adaptation tracking

Tracking Adaptation in Livestock Systems (TAiLS)

The Tracking Adaptation in Livestock Systems (TAiLS) is a web-based tool developed by ILRI to enable national governments to monitor and report on their livestock sectors' adaptation efforts and outcomes. The primary purpose of TAiLS is to assist countries in fulfilling their commitments under the Paris Agreement, including the submission of Nationally Determined Contributions (NDCs) that outline their plans for climate mitigation, adaptation, and resource mobilization for climate action. It aligns with the Paris Agreement's Global Goal on Adaptation, which emphasizes the collective ambition of countries to reduce vulnerability to climate change and enhance adaptive capacities and resilience.

In addition to showcasing progress in adaptation, the tracking provided by TAiLS also supports the mobilization of funding for adaptation initiatives. The tool was developed through collaborative and iterative processes involving scientists from ILRI, research partners, policymakers, and livestock keepers in Kenya, Ethiopia, and Uganda. This close collaboration aimed at ensuring that the adaptation tracking indicators incorporated in the tool were user-friendly, fit for purpose, and aligned with each country's specific plans and priorities. This approach led to substantial support from government stakeholders.

Furthermore, by aligning the tool with existing government data collection systems, it increases the likelihood of its continuous utilization while minimizing the burden of data collection and reporting. The TAiLS tool covers three essential dimensions of adaptation tracking namely, climatic hazards, climate change impacts, and adaptive capacity and actions. It encompasses approximately 96 indicators associated with these dimensions to capture changes within and across various populations, including natural and social systems. Examples of these indicators include the quality of pastures and relevant institutional reforms.

The TAiLS tool helps the tracking of adaptation efforts by:

1. Encompassing adaptation across scales and incorporating diverse indicators, therefore providing a comprehensive view of how adaptation is progressing. This comprehensive approach allows governments and donors to obtain a more nuanced understanding of adaptation efforts and outcomes. It enables them to gain insights into the effectiveness of different strategies and interventions, identify areas that require more support, and determine where resources can be best utilized.
2. Facilitating comparisons among different geographical regions and enabling stakeholders to identify disparities in adaptation actions and outcomes. This comparative analysis empowers countries to advocate for increased

support in regions where it is most needed and can have the greatest impact. By showcasing countries' actions or inactions in utilizing existing resources, the TAiLS tool promotes accountability and encourages more targeted and effective allocation of resources for adaptation.

As a web-based tool exclusively accessible to governments, authorized users of the TAiLS tool require credentials to access it. The tool functions by allowing accredited users to upload data, which undergoes validation, processing, and visualization to demonstrate temporal progress and spatial variations. It provides an overview of aggregated adaptation progress at the national level and allows for comparisons between countries. This empowers governments not only to assess their own performance but also to advocate for additional support based on identified gaps in adaptation. Therefore, the TAiLS tool contributes to informed decision-making and adaptation planning at the government level. Additionally, the tool has been designed to meet international reporting requirements. It also facilitates the tracking of livestock sector progress, capturing changes within and between populations and different aspects of natural and social systems, such as environmental quality and economic conditions. Highlighting the role of livestock in adaptation can influence discussions surrounding the involvement of livestock in climate action at both national and global levels.

Overall, the TAiLS tool offers a valuable platform for monitoring and evaluating adaptation efforts, allowing governments and donors to obtain a more comprehensive understanding of adaptation progress, informing decision-making about resource allocation, and driving effective action where it is most needed.

Stocktaking for National Adaptation Planning (SNAP)

Stocktaking for National Adaptation Planning (SNAP) was developed by the German Agency for International Cooperation, GIZ, to evaluate, improve, and keep track of a nation's capacity for planning its adaptation, to accompany the United Nations Framework Convention on Climate Change (UNFCCC) National Adaptation Plans (NAP) technical guidelines. The tool targets technical support units from ministries, donor agencies, organizations supporting NAP planning, and other stakeholders.

The main component of the tool is an assessment of the country's needs and capacities while allowing for a critical perspective on the overall NAP process. It provides a stock-take of a country's planning capacities, both existing and intended, and aids in determining the country's starting point for launching the NAP process; as the country heads towards the achievement of the NDCs goals that contribute to achieving the Paris Agreement's goals.

SNAP is implemented through one- or two-day workshops ensuring all stakeholders involved fully participate. As the basis for assessment, the tool uses seven relevant success factors that are outlined by various development partners. These are:

1. *Climate information:* data about climate variability and changes, and associated impacts, including perception studies.

2. *Human and institutional capacities:* the ability of institutions and stakeholders to coordinate adaptation processes, including using and managing climate information.

3. *Long-term vision and mandate:* establishing a shared understanding of long-term objectives for national and local development that considers climate change with a mandate to match key processes with this vision.

4. Implementation: scope, effectiveness, and strategic orientation of measures put in place on the ground, both policies and projects, to increase resilience and/or lessen vulnerability to climate change.

5. *Mainstreaming:* integrating climate action and adaptation into development processes at all planning levels.

6. *Participation:* involving representatives from government, private entities, civil society, local community groups, women, and disadvantaged groups.

7 *Monitoring and evaluation:* climate change impact, financial resources, and adaptation results. It provides information for adaptation planning and decision-making.

Process of assessment using SNAP

- Stakeholders relevant to the NAP process are asked to give input to assessing the country's current situation and strategic goals founded on the seven factors above.
- For each success factor, the tool submits three test questions to evaluate the country's capacity to engage in a national or subnational adaptation plan. Every question has three elements: a quantitative score for both the current capacity, the intended capacity, and a qualitative justification for the scores given.
- The stakeholders' evaluation or score of the success factors is inserted into the Excel tool and generated into an Excel-based radar chart for visual representation. Careful analysis and documentation of both quantitative and qualitative information are required for a contextual and comprehensive picture of a country's capacities. And transparency is emphasized in report writing.

Different methods of conducting a SNAP assessment include:

- Participatory workshop–the workshop setting
- Interview mode–where the workshop setting is inapplicable e.g., when small groups are involved.
- Reflection mode–when SNAP is used with other tools to identify urgent issues and hindrances of a successful adaptation policy process.
- Combination of workshops and interviews.
- SNAP was first implemented in seven countries (Albania, Grenada, Mauritania, Thailand, Togo, Uttarakhand in Inda, and Guyana). Insight from the case studies has been used to guide the expansion and improvement of the tool. SNAP has been one of the most widely used capacity assessment and support tools within the NAP process.

GIZ has supported over 20 countries in progressing their NAP process, but this depends on different factors and situations. The use of SNAP depends on the purpose of the assessment and the country's adaptation context.

The general uses of the SNAP tool include preparing and conducting a SNAP assessment, preparing, and conducting a NAP roadmap development exercise based on SNAP outputs, and using the outputs within the NAP process.

Adaptation Monitoring and Assessment Tool (AMAT)

The Adaptation Monitoring and Assessment Tool (AMAT) is a tracking tool for monitoring the progress of the Least Developed Countries Fund (LDCF). The tool tracks the progress and achievement of specific project outcomes and output indicators established at the portfolio level under the LDCF/Special Climate Change Fund (SCCF) results framework for the Global Environment Facility (GEF)-5. It includes specific examples of outcomes and output indicators for different sectors and adaptation objectives. The tool also has a comprehensive drop-down menu suggesting indicators to project proponents.

AMAT has been applied to assess climate change vulnerabilities and design effective responses for adaptation. The tool is designed to compile and distribute information about climate risk nationally. AMAT can generate information relevant to sustainable land management, human health and nutrition, and conservation of coastal zone fisheries. It can be an instrument to monitor indicators related to biodiversity, marine, water, agriculture, health, tourism, and culture and heritage.

AMAT is applied three times during the project's life: baseline, mid-term, and completion/end-term. As the projects and programs advance, the LDCF/SCCF will have enough data points to evaluate, reassess key indicators, and incorporate adjustments to improve how portfolio results are tracked for adaptation.

AMAT has since undergone revision based on lessons learned over application over the years, reducing the number of indicators from 52 to 14. The indicators and associated units are clearly defined. It also provides guidelines and methodologies for each indicator. These changes were intended to ensure that each indicator is used consistently to ease the aggregation and communication of progress and outcomes across a significant number of projects and programs.

Information is provided by government agencies and institutions, and the reports and information generated are included in the state of the environmental report and support decision-making.

Repository of adaptation indicators

Developed by the GIZ and the International Institute for Sustainable Development (IISD), the repository of adaptation indicators is intended to illustrate possible adaptation indicators and their application context, thereby supporting the selection and context-specific formulation of indicators. Specifically, this repository seeks to provide support to adaptation and development as well as monitoring and evaluation (M&E) experts who are involved in developing and implementing adaptation M&E systems at regional, national, and subnational levels. It systematically presents various indicators from a range of sectors that track different aspects of the adaptation context, process, and results to determine if adaptation strategies or investments are meeting their objectives. Users can conduct tailored searches within the repository looking for specific 'sector' indicators or for indicators with a particular 'adaptation focus'. An Excel file of the indicator repository is available on http://www.adaptationcommunity.net/ under Monitoring & Evaluation: Repository of Adaptation Indicators. The repository offers users numerous example indicators that might be used directly – or with some adjustments – for tracking climate adaptation in their context. Progress in adaptation can be interpreted in different ways, covering a range of sectors, and focusing on different types of activities.

A relevant selection of Indicators will depend on several factors including:

The purpose of using an indicator: what aspect of adaptation the user is trying to monitor and evaluate. Is it to track the context, the progress in implementing adaptation strategies or actions, the results of such actions, or some combination thereof?

Relevance to the user's specific context: The indicators selected should be suited to the vulnerability and risk context that the user is trying to monitor and evaluate. Scale should also be considered, i.e., whether an indicator focuses at national, sectoral, or local levels.

The resources and capacities available for developing and applying indicators: The relative ease of measurability, data availability, acquisition costs, etc. compared to the time, money, and personnel available. The more difficult or cumbersome an indicator is to track, the less likely it is going to be applied. This may mean accepting trade-offs, where simpler and less descriptive indicators are selected over more sophisticated and representative indicators. It may also be wise to start with a smaller number of indicators and build up the indicator set as experience with adaptation M&E grows.

Alignment with existing M&E systems: Related to the previous point but worth mentioning, the user should also consider information that is already being gathered by existing M&E systems when selecting indicators. That is, there may be national or subnational programs in place that gather relevant data and information on demographic trends, environmental conditions, economic performance, poverty indices, etc. These may feed relevant information into an adaptation M&E system.

There are three categories of adaptation indicators: (1) adaptation context (focus on observed climate impacts on socioecological systems); (2) adaptation actions (implementation strategies); (3) adaptation results (possible results of adaptation, i.e., increases in yields and incomes).

Tracking Adaptation in the Agricultural Sectors (TAAS)

The Tracking Adaptation in the Agricultural Sectors (TAAS) framework was developed by FAO. It tracks progress towards climate change adaptation at the national level. The TAAS 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, socioeconomics 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.[1]

Four major categories of indicators are identified:

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 freshwater 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: 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 can produce desired outputs in a sustainable manner.

Socioeconomics: 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.

Institutions and policies: 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 crop and livestock farming, fisheries, aquaculture, and forestry sectors helps create an enabling environment for adaptive capacity building.

Within each indicator category, there are subcategories of indicators. A distinction is made between quantitative and qualitative indicators, as well as between process and outcome indicators. The choice of a set of individual indicators for each subcategory largely depends on the national context in which the tracking process takes place. Each indicator category is assigned a score between 0 (very low adaptation) and 10 (very high adaptation). The final score depends on a system's performance against several 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.

1 A more detailed description of the TAAS framework and methodology can be accessed here: https://www.fao.org/3/i8145e/i8145e.pdf.

The TAAS approach

The selection and use of indicators for TAAS consists of six interrelated steps:

Step 1: Preparatory phase. This stage involves national level consultations on the objectives and goals of adaptation tracking exercise. In this phase, discussions are initiated on the roles and responsibilities of relevant stakeholders. Decisions are then made on the criteria for selection of indicators. The periodicity of the tracking and reporting is also discussed.

Step 2: Selection of indicators and assignment of weights. At this stage, information is collected and analysed on the priority adaptation actions and targets as outlined in NDCs, national communication and other relevant documents. The availability of quantitative and qualitative information to track adaptation progress is verified. Indicators are then selected under TAAS categories and subcategories followed by the assignment of weights to indicators based on their relative importance within each subcategory.

Step 3: Information gathering. Data and information gaps for measuring selected indicators are identified and data sources listed. Data is then gathered from reliable and analytically sound sources. The data are then consolidated into the TAAS indicator framework and procedures established for the regular updating of the information.

Step 4: Setting baselines, targets, and ranking intervals. A baseline is established for each indicator. A target is then set for each indicator based on national priorities and goals. Minimum and maximum values as well as ranking intervals are assigned to each indicator. Finally, verification is done for coherence of baselines, targets, and ranking intervals.

Step 5: Analysis and assessment of progress towards adaptation. The scores of the indicators are analysed and consolidated across subcategories and categories. Analysis of the progress towards adaptation is done. Further, an analysis to verify synergies and potential unintended consequences across indicators and categories is completed followed by an evaluation of the state of the adaptation process and outcomes to identify gaps and needs.

Step 6: Reporting and informed policymaking. Results of the assessment are communicated to the policy process. Measures to address identified gaps and opportunities are designed. Priority adaptation actions are redefined. Finally, reporting and information sharing to global climate change processes is done.

The Pilot Program for Climate Resilience (PPCR) monitoring and reporting system

As the scale and volume of climate change adaptation finance grows worldwide, so do the number of climate resilience activities and the need for data to inform decision-making and demonstrate progress toward national, regional, and international goals, such as the Sustainable Development Goals and the Paris Agreement. Countries require strong M&E systems to collect and report accurate, timely, and harmonized data that can be used to strengthen projects and programs, promote accountability, and gain financial support. The Pilot Program for Climate Resilience (PPCR), a targeted program of the Climate Investment Funds (CIF), is a pioneer in climate finance monitoring and results reporting.

Created in 2008, PPCR is a concessional financing mechanism designed to pilot and demonstrate ways to integrate climate risk management and resilience into core development planning and complement ongoing activities in developing countries around the world. It has established a monitoring and reporting (M&R) system that supports recipient countries in their efforts to track progress in climate resilience action.

PPCR has five main indicators: (1) degree of integration of climate change in national, including sector, planning; (2) evidence of strengthened government capacity and coordination mechanism to mainstream climate resilience; (3) quality and extent to which climate-responsive instruments/ investment models are developed and tested; (4) extent to which vulnerable households, communities, businesses, and public-sector services use improved PPCR-supported tools, instruments, strategies, and activities to respond to climate variability or climate change; (5) number of people supported by the PPCR to cope with the effects of climate change.

PPCR follows seven steps:

Step 1: Compose in-country stakeholder group. Every year, the PPCR country focal point identifies at least two representatives from these PPCR stakeholder groups to participate in the annual scoring exercise: national government (e.g., national climate change agency, priority sector ministries), private sector, civil society (e.g., NGOs), traditional authorities/ indigenous groups, academic and research institutions. Representatives of each stakeholder group should be knowledgeable about climate resilience programs in the nation and include both women and men.

Step 2: Convene a scoring workshop. The PPCR country focal point then invites the stakeholders defined in Step 1 to a scoring workshop to assess the Strategic Program for Climate Resilience (SPCR) progress on the five core indicators. It is held during the first half of the year (between January and June) to ensure consistency with the PPCR annual reporting cycle.

Step 3: First-year workshop: Establish scoring foundation. Establish scoring criteria for Indicators 1, 2, and 3. Before starting the scoring process, the PPCR country focal point invites participants to establish scoring criteria (from 0 to 10) for each sub-question on the three scorecards used to assess Indicators 1, 2, and 3. This step is only undertaken once for each indicator, typically at the beginning of the first year's scoring workshop. Scoring criteria often reflect the development process that a country expects to undertake to reach its target outcome(s). In this sense, criteria 0 to 10 might reflect the 10 major milestones that the country expects to meet toward the end-line outcome. Scoring criteria take into consideration the unique institutional and policy ecosystem of each country. This means that a score of 7 for one country will not carry the same meaning as a score of 7 for another country. Once scoring criteria are set, the PPCR country focal point leads the group in establishing baselines and expected results (or targets) for the five core indicators.

Step 4: Subsequent-years workshops: Prepare and present the evidence base. Before scoring exercises begin, the PPCR country focal point presents workshop participants with a body of evidence that they can use to assess progress and inform their scoring decisions. This evidence base consists of information and data detailing SPCR performance during the reporting period. The PPCR country focal point gathers this information and data prior to the workshop using the appropriate methods for each core indicator. Once completed, the PPCR country focal point stores all evidence base materials for future reference.

Step 5: Subsequent-years workshops: Assess progress. Scores for Indicators 1 and 2 are determined by consensus and the aggregated project-level data for Indicators 3, 4, and 5 is verified.

Step 6: Quality assurance. The PPCR country focal point is encouraged to invite a wider group of stakeholders to review the country results report, including the scores on the PPCR scorecards, before sharing the results with the CIF Administrative Unit. Based on national context, each country determines how to conduct this review. Generally, it tends to be less technical, more high level to raise awareness of PPCR in-country activities.

Step 7: Submit results report to the CIF Administrative Unit. The PPCR country focal point submits the annual country results report to the CIF Administrative Unit by no later than June 30 of each year. This includes all national level scorecards and tables for the five core indicators and a summary of the annual scoring workshop, describing participation, scoring criteria and processes, and quality assurance measures. The CIF Administrative Unit collects and aggregates country reporting from all PPCR countries, as well as MDB reporting, to produce a synthesis PPCR annual operations and results report that it submits to the PPCR subcommittee for approval during its fall meeting every year.

Tracking Adaptation and Measuring Development (TAMD)

The Tracking Adaptation and Measuring Development (TAMD) is a twin-track conceptual framework that countries can use to assess the effectiveness of climate change adaptation. It evaluates both institutional climate risk management (Track 1) and adaptation and development performance (Track 2). The processes in both tracks are linked, so the framework makes it possible to assess not only whether development outcomes bring better local climate resilience but also whether they aggregate at larger scales to contribute to climate-resilient development. This methodology has been developed and tested in Kenya, Tanzania, Nepal, Pakistan, Mozambique, Ethiopia, and Cambodia. TAMD was developed by the International Institute for Environment and Development (IIED) and partners. TAMD can be used to evaluate how far, and how well, climate risks are managed at international, national, and subnational scales. In addition, it can be used to assess whether development outcomes bring better local climate resilience, and whether that aggregates at larger scales to contribute to climate-resilient development. TAMD can be used by government officials at local and national levels, NGOs, and development partners.

Self-evaluation and Holistic Assessment of climate Resilience of farmers and Pastoralists (SHARP)

Self-evaluation and Holistic Assessment of climate Resilience of farmers and Pastoralists (SHARP) was developed in 2014 by the FAO and partners, including practitioners, academics, and members of civil society. It was first launched as an open-source tool in 2014 and later released in 2017 as an offline survey tool. The tool has empowered many nations to achieve the enhanced transparency framework requirement for reporting in the Paris Agreement.

Most resiliency tools available emphasize environmental and agronomic conditions. SHARP involves a holistic assessment of how the household is resilient to climate change, depending on the knowledge and priorities of the people. The framework used by SHARP makes it possible to do comparison analysis, strengthening the productive capacity of the small-scale household for climate change adaptation.

SHARP assesses the climate change resilience of smallholder farmers and pastoralists by identifying the main weaknesses and strengths of farming systems and agriculture-based households, building on their flexibility, learning, and knowledge of farmers and pastoralists in a participatory manner. SHARP also helps in monitoring and evaluating climate change adaptation in agriculture sectors and to further research in academia.

The survey is paper-based and an offline Android/ tablet version, a combination of self-assessment and academic review of livelihood components. It contains 54 questions in total, 26 of which are compulsory to fully assess resilience.

SHARP uses a modular approach where each module explains different features of farm systems that predict resilience. Resilience looks at three features:

1. Exposure to a hazard
2. Sensitivity to its effects
3. Adaptive capacity to deal with shocks.

The tool is implemented in 2–3 phases:

Phase 1 involves adjusting the survey to fit the context of the assessing objects and conducting a field survey (participatory self-assessment by the farmers and pastoralists) to assess the climate change resilience of the households.

Phase 2 involves aggregating and analysing data to find climate resilience and adaptive capacity at different scales and levels and includes interaction with local government representatives and policymakers to assess the efficacy and gaps of agricultural and pastoral policies.

Phase 3 is optional. Information coming from Phase 2 is incorporated with geospatial climate information to support decision-making in designing appropriate policies and measures to increase climate resilience in small-scale households and agroecosystems.

SHARP outputs include all-round and in-depth information on farm systems, such as adaptation and mitigation actions, types of crops grown or livestock kept, gender dynamics, a rank of farmers' priorities for adaptation and mitigation actions, a ranking of priority actions for strengthening resilience, georeferenced data and information (both quantitative and qualitative), information on households access to and management of natural and other productive resources, and a numeric score of resilience and adaptive capacity for every feature of the farm system under assessment. Different geographical scales like community, district, province, or attributes such as sex of the household head, production system type, land use type, and ethnicity can be used in the assessment.

SHARP has been applied in five countries: Mali, Uganda, Angola, Burkina Faso, and Senegal. SHARP is informative and favourable regarding resilience performance and agricultural development in rural households.

Following a technical review of the tool at the end of 2017, to address the challenges identified and incorporate feedback, SHARP+, a short version of the questionnaire with an improved, more robust scoring system was developed.

Presently, the survey is on the Kobo toolbox with a 33-question module survey, 17 of which are the core modules. It has new thematic modules, including forest management, health, food insecurity experience scale, fish production, involuntary resettlement and replacement, housing quality, and sanitation. The mobile collection is easily customizable, and georeferencing is improved.

Resilience Index Measurement and Analysis (RIMA)

Resilience Index Measurement and Analysis (RIMA) is a quantitative tool developed by FAO. The tool aids in the analysis of how different households manage and adapt to climate shocks. It also compares households and how their responses to stressors vary in each location. The RIMA framework offers crucial evidence for the improved design, implementation, monitoring, and evaluation of support and aid to vulnerable populations according to their specific needs.

RIMA helps generate evidence that facilitates the monitoring and evaluation of programs. It achieves this by examining internal and external factors that contribute to resilience. Additionally, the tool aims to identify appropriate strategies by addressing key questions, including identifying the most vulnerable individuals or groups, determining the geographical areas that require targeted investment, identifying specific dimensions of resilience that need support, and assessing the extent to which interventions have enhanced target populations' resilience.

The aims of RIMA include to:

- Calculate the resilience score of different communities to determine their resilience to food insecurity.
- Identify the factors that influence the resilience capacity of the target community.
- Establish effective strategies that can enhance and improve the community's resilience capacity.
- Establish a baseline value that can be used as a reference point to measure and compare future changes in resilience.

These objectives collectively aim to assess and understand the resilience of communities, identify factors, develop effective strategies, and establish a benchmark for monitoring and evaluating changes in resilience over time. Target users include policymakers, local and regional government officials, food program managers, and officials.

Methodology

RIMA is predominantly a quantitative approach for measuring the household Resilience Capacity Index (RCI). This index enables stakeholders to understand the reasons behind differential coping abilities among households in the face of shocks and stressors such as climate change, which might lead to food scarcity among communities. The four pillars of RCI are social safety nets, assets, adaptive capacities, and access to basic services. ***Social safety nets*** evaluate the ability of households and communities to access or receive help provided by charity organizations such as NGOs and even assistance from families and friends. ***Assets*** include the productive and non-productive community and household assets such as houses, livestock, and land. The ***adaptive capacities*** show the flexibility of households when faced with situations that force them to adapt to new livelihood ways and strategies. The ***access to basic services*** pillar evaluates the ability of the community and households to access basic services such as infrastructures, health, and learning facilities.

The target population is sampled, and the data is collected and analysed to produce results that are interpreted to provide the resilience capacity of communities. The data can be compared between communities in different areas to show the communities that are most and least vulnerable to any stressors that might affect food security, such as climate change. Such information helps community planners and responsible government groups to plan accordingly on how to strengthen the resilience of different communities.

4.1.4 Tools and frameworks for monitoring climatic shocks, forecasting and early warning, and dissemination of climate information services

KAZNET

KAZNET is a tool developed by the Index-Based Livestock Insurance (IBLI) team at ILRI as a digital platform for crowdsourcing data in remote locations in the pastoralist regions. KAZNET is an open-source platform with two major components (web and mobile application). The web application provides an interface to design, manage, and approve tasks and access the submitted data. The mobile application has integrated the tasking wrapper into ODK software to provide an interface that allows users to carry out and submit tasks and receive feedback for the submissions.

Microtasking platform process

The information that can be useful and needed by the community is translated into specific data needs. The administrator then designs the tasks on the web application. It includes developing a survey form and embedding relevant controls. The survey form also has information on how often the survey can be completed and the reward for completing the survey. The system administrators activate the tasks for access to the users/data collectors, also known as the 'contributors'.

The contributors then download the survey form on the mobile application and perform the available tasks and upload them after completion. The contributors can receive feedback from the administrator on the tasks that they have submitted.

On the web application the administrator reviews the tasks submitted for quality control and compliance. The feedback tasks are generated and sent to the contributor. After that, the reviewed tasks are aggregated for reward and output analysis. The data can now be available for analysis and visualization in near real time.

The KAZNET platform is useful in remote areas where the conventional methods of data collection can be expensive and lead to underrepresentation. KAZNET provides a low-cost approach to collecting and disseminating accurate livestock information in a timely manner to help producers sell their livestock at better prices. Using KAZNET, contributors can monitor rangeland conditions on the data collection clusters called sentinel zones to establish the impacts of climate shocks on rangelands and livelihoods.

The tool can therefore be used to support decision makers in identifying risks associated with climate change and prioritize different adaptation measures to reduce the vulnerability of local communities to climate change risks.

Intelligent Agricultural System Advisory Tool (ISAT)

The Intelligent Agricultural System Advisory Tool (ISAT) was developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in partnership with Indian Meteorological Department, Microsoft India, and Acharya NG Ranga Agricultural University. It is an advisory tool that provides precise advice to farmers on their phones.

One strategy for assisting smallholder farmers to cope with climate change and variability and change is the provision of climate services to improve decision-making around agricultural system planning and management both pre-season and in-season. For timely, location-specific, and actionable information service to reach millions of farmers in a range of different conditions innovative solutions such as ISAT are required.

ISAT employs a decision tree approach, a structured and systematic approach to decision-making that accounts for the insights gained from the analysis of past climatic conditions, current environmental conditions, climate and weather forecasts, crop systems, and information on the soil. It performs data analytics using real-time data, implements the decision tree approach, and creates and sends messages to farmers and other stakeholders. The messaging system performed excellently in analysing and selecting appropriate location-specific messages from the database and sending them to the registered farmers' phones.

Farmers acknowledge that their main climatic change risk is erratic rainfall patterns, making it difficult to plan for uncertainty. ISAT can provide weekly pre and in-season advisories to aid farmers in making informed decisions. Where ISAT has been applied, farmers found messages sent via ISAT were reliable, relevant, and of high frequency, helping them to manage their farms on time with minimal risk, hence increasing their productivity.

What separates ISAT from other SMS with climate information is that it blends climate analysis, forecasts, and real-time local soil, crop, and management information using a scalable methodology for millions of farmers. Using ISAT, farmers have also been able to make investment decisions like whether to lease farming land for higher profit and produce.

Africa RiskView

The Africa RiskView tool was developed by the World Food Programme. It offers an online tool and a more flexible desktop application. This tool translates globally available rainfall data, crop parameters and livelihood information into food security outlooks. The Africa RiskView tool is designed to interpret different types of weather data, including rainfall estimates, and information about crops, such as soil and cropping calendars. These data are then converted into meaningful indicators for agricultural production and pasture and applied to the vulnerable populations that depend on rainfall for crops and rangeland for their livelihoods. Africa RiskView then uses this information to estimate how many people may be directly affected (or have been affected) by drought or deficit rainfall in each season. It also calculates response costs to aid financial planning and facilitate better resource allocations before on-the ground needs assessments are produced. Governments also use Africa RiskView to understand the cost of different risk transfer options. It also serves as a component of a technical support package being provided for a potential pan-African Disaster Risk Pool, allowing participating countries to immediately access funds in the event of an extreme drought, flood, or storm. In addition to providing a financial early warning tool, identifying, and quantifying risk in this objective way can also help countries and their partners direct appropriate drought response actions and target food security investments.

Africa RiskView utilizes various rainfall estimates (RFE) datasets, including RFE 2.0 and African Rainfall Climatology v2 (ARC2) from the Climate Prediction Centre (CPC) at the National Oceanic and Atmospheric Administration (NOAA). Additional datasets are continuously incorporated as new ones become available. These datasets enable users to access real-time rainfall estimates, calculate cumulative rainfall, and analyse rainfall across different spatial scales. Historical rainfall datasets are available from 1983 to the present.

Africa RiskView uses the Water Requirements Satisfaction Index (WRSI) to gauge the impact of rainfall shortage on crop yields and pasture availability. WRSI, developed by FAO and widely used in Africa, translates satellite-based rainfall information into a spatial drought index.

CCAFS Regional Agricultural Forecasting Toolbox (CRAFT)

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) Regional Agricultural Forecasting Toolbox (CRAFT) is designed to predict crop yields by combining crop models that simulate crop growth and development with the Climate Predictability Tool (CPT). The CPT is a software package that constructs seasonal climate forecast models, validates models, and generates forecasts based on updated data. By providing a robust and advanced information tool, CRAFT empowers farmers and decision makers in food security to effectively manage climate risks within the agricultural season. CRAFT tackles the lack of accessible tools that integrate seasonal climate forecasting and crop modeling to cater to the needs of farmers, scientists, and policymakers. It achieves this through open-source platforms that can be customized to meet specific user requirements. This adaptability and flexibility make CRAFT a valuable tool for diverse end users. CRAFT has been applied in Ethiopia under the Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA) project.

NextGen Agricultural Drought Monitoring and Warning System (NADMWS)

The problem of addressing the impacts of ongoing and severe droughts is twofold. First, there is a lack of timely and accurate climate information regarding when and how countrywide drought conditions occur. Second, even when such information is available, it is not easily accessible or presented in a format that allows decision makers in the humanitarian field to take appropriate action. The NextGen Agricultural Drought Monitoring and Warning System (NADMWS) directly confronts these challenges. By utilizing satellite-based remote sensing technology, along with comprehensive land use maps, seasonal forecasts, national crop statistics, crop phenology, and other relevant data specific to each country, users now can monitor agricultural areas or specific ‘hotspots’ at national, regional, and local levels that are highly likely to experience water scarcity. Importantly, the system automates and simplifies the analysis process that would typically be performed by a remote sensing expert, making the data more accessible and user-friendly for individuals who are not experts in remote sensing.

In addition to monitoring and early warning, the NADMWS also offers decision support tools for farmers and policymakers. These tools provide customized recommendations and strategies based on the current and predicted drought conditions. For example, the system can suggest optimal crop varieties that are more resilient to drought, recommend specific irrigation techniques, or advise on land management practices to minimize the impact of drought on agricultural productivity.

Invasive Species Forecasting System (ISFS)

The Invasive Species Forecasting System (ISFS) is a web platform that offers decision support tools such as habitat suitability maps for invasive species, probability maps to guide early detection, rapid data access. It also documents the current distribution of species.

The spread of invasive species is one of the most adverse environmental, human health, and economic problems facing different parts of the world today. National Aeronautics and Space Administration (NASA)'s Science Mission Department, in partnership with various departments of Interior and bureaus such as the US Geological Survey (USGS) and the Bureau of Land Management (BLM), attempts to address this challenge. NASA and USGS developed the ISFS to control and manage invasive species. The ISFS provides computational support for processing data and other processes found in ecosystem modeling frameworks and applications.

The ISFS systems quickly generate habitat suitability maps for geographic areas of concern, such as in parks, forests, or reserves, by allowing users to input the point of occurrence of a selected plant species. This level of decision product can help protect the environment from invasive species and monitor and develop strategies to control invasive species in a particular environment.

The ISFS was specifically designed to produce data structures, offer operating system interfaces, and network interfaces, and provide solutions to the constraints involved with habitat suitability modeling. The web service concept enables the publication of results and reports. The system offers standard programming interfaces which allow users to use various applications.

In addition to generating predictive models and maps, the ISFS system can develop merged data sets through its Invasive Species Data Service (ISDS) to combine field data with other satellite data to produce geospatial datasets. The constant development of the platform has been customer driven, with constant community needs assessments. Previous improvements have been made to its computational performance and data access.

Some of the end users of the ISFS include resource managers, environmental researchers, and policymakers involved in managing and mitigating the impact of invasive species.

MaxEnt (Maximum Entropy)

MaxEnt (Maximum Entropy) is an open-source software package used to analyse species distributions by applying a machine learning (ML) technique called maximum entropy. MaxEnt was originally developed by Steven Phillips, a computer science researcher, and Robert Schapire, an ML expert, but is now managed by the Center for Biodiversity and Conservation (CBC) at the American Museum of Natural History (AMNH). MaxEnt uses presence-only data, that is, data that target species known to inhabit, with no information of the location where the species is absent.

MaxEnt is now widely used because it produces a better predictive performance compared to other species distribution models that use presence-only data. The model predicts geographical distribution by establishing a relationship between species' presence locations and prevailing environmental conditions in these locations. It predicts the occurrence of species, accounting for the constraints in the environment variables in specific known locations.

How MaxEnt works

MaxEnt uses two main components: The presence-only data (list of species presence data) and environmental predictors (e.g., rainfall, temperature) in the locations where the species have been observed. From the two data inputs, MaxEnt calculates two probability densities, one in which the relative environmental suitability for the species present for each point is estimated and two across the whole study region according to the background points characterizing the available environment. MaxEnt then selects the distribution that maximizes similarities of the environmental characteristics between the locations where species are known to be found and the whole environment. It also gives a logistic transformation (this relies on the assumption of prevalence) of the raw output while considering the number of locations that are occupied by the species.

MaxEnt has been utilized by the ecological modeling community for the past 20 years as their preferred tool to map and model ecological niches and distributions of species while accounting for maximum entropy through its machine-learning algorithm. It also uses a 0.5 prevalence value for logistic transformations meaning the species are present in half of the possible locations, which does not apply to the rare species.

Researchers and conservation planners can use MaxEnt for conservation planning to facilitate species conservation. The model is also capable of projecting shifts in species distribution under different climatic conditions. Climate change already has substantial effects on species and ecosystems; therefore, researchers can identify and prioritize species at risk/ endangered species using the software.

Participatory Integrated Climate Services for Agriculture (PICSA)

Participatory Integrated Climate Services for Agriculture (PICSA) is an approach that has been developed for extension agents to enable them to improve the support provided to farmers considering climate information relevant to the locality of the farmers. PICSA goes beyond climate prediction, because in the approach, farmers begin long before the start of the season exploring several options based on historical climate information for their locality. This involves using participatory planning tools to help farmers make informed decisions based on precise climate and meteorological information specific to their localities and options for agriculture, livestock/fishery production and other locally relevant livelihood options.

The PICSA approach aims to strengthen the capacity of targeted stakeholders and to enhance access to climate information services and validated CSA technologies in Africa. PICSA can help farmers and livestock keepers to better anticipate climate-related events and take preventative actions, with better access to climate advisories linked to information about effective response measures. This would help communities better safeguard their livelihoods and the environment.

The PICSA approach

The training program lasts for five days and employs an interactive and participatory approach. In the initial three days, various modules and sessions are presented through PowerPoint slides. On the fourth day, a field trip is arranged to apply the approach in a specific location. The final day of the program involves a review of the field trip, including lessons learned, as well as discussions on the planning and monitoring of the practical implementation.

Famine Early Warning Systems Network (FEWS NET)

FEWS NET was established in 1985 by the United States Agency for International Development (USAID) to respond to famines in East and West Africa by providing early warning of potential food security crises. FEWS NET provides timely, accurate, evidence-based, and transparent early warning information and analysis of current and future acute food security in 30 world's most food insecure countries. It informs decisions on planning and responding and reporting on humanitarian food crises.

FEWS NET and its partners continue to monitor increasingly complex factors affecting food security, such as weather and climate, conflict, agricultural production, markets, and nutrition. FEWS NET provides integrated food security analysis that predicts outcomes 6-12 months ahead.

The target users include governments, relief agencies, NGOs, researchers, and journalists.

FEWS NET publishes and shares:

- Country-specific integrated food security analysis reports on current and forecasted levels of acute food security.
- Alerts on emerging or likely acute food insecurity crises.
- Specialized reports on factors affecting food security.

FEWS NET uses scenario development methodology to provide early warning on food crises to decision-makers. The methodology relies on rigorous analysis of current conditions, assumptions of future conditions, comparison of their possible effects, and possible responses. Scenario development relies on regular data collection, and assumptions are improved as new data becomes available, reducing uncertainty.

Steps to scenario development

1. Set scenario parameters.
2. Describe and classify current food security.
3. Develop key assumptions.
4. Describe impacts on household income sources.
5. Describe impacts on household food sources.
6. Describe and classify projected household food security.
7. Describe and classify projected area food security.
8. Identify events that could change the scenario.

KAOP (Kenya Agricultural Advisory Platform)

KAOP is an online platform developed by Kenya Agricultural and Livestock Research Organization (KALRO) to provide weather forecasting and advisory services to farmers in Kenya. KAOP uses geo-data to give real-time and location-specific advisory, where farmers and other stakeholders use the information to make informed farming decisions. The platform is designed to provide weather advisory, agronomic advisory, and market information. The users include crop farmers, livestock producers, NGOs, extension officers, aggregators, input suppliers, and agriculture commodity traders.

Farmers using KAOP can reduce losses associated with climate change by using information coming from the platform to create contingency plans in cases of foreseen climate change risks.

The platform is accessible through a web browser www.kaop.co.ke, or a mobile app in the Google Play store. The system also reaches farmers in remote areas through an SMS module. The SMS advisory system has sent numerous agronomic advisories to farmers based on weather forecasts.

To receive location-specific advisory and forecast you select your County, sub-County, and Ward. The platform provides predictions on precipitation and temperature and plots dynamic charts for the next 14 days.

Picture-Based Advisories (PBA)

PBA was developed by IFPRI to complement picture-based insurance (PBI)-A crop insurance innovation that relies on farmers to periodically upload pictures of their field throughout the growing insurance, where the pictures are analyzed to assess crop damage and determine insurance payout.

The PBI app and website were updated to include features for advisory messages.

PBA is designed to deliver advisory messages by local agronomic experts for farmers participating in PBI based on issues observed in pictures submitted by farmers. Each advisory message is sent through two channels, an incoming advisory tab on a smartphone app and an SMS text.

A team of experts monitors the incoming pictures from farmers and issue advisory. Where PBA has been applied in Kenya, farmers send pictures of crops then the experts use the pictures submitted in the last 14 days to send advisory messages on knowledge of the crop, management practices, recent or forecasted weather, and availability of inputs, among others. The advisory considered pictures submitted by the neighbors if a farmer has not submitted pictures in the last 14 days. A standard advisory was sent based on the general patterns observed in the region where the pictures are unavailable.

PBA is tailored to individual farmers, enhancing timeliness and better targeting in remote extension services. Coupled with insurance, it can lower farming risks associated with climate change by reducing barriers to improved agricultural practices adoption.

4.1.5 Tools and frameworks for natural resource management

Climate Change Response Framework (CCRF)

The Climate Change Response Framework (CCRF) is a collaborative approach where the United States Department of Agriculture (USDA) Forest Service works with other partners to incorporate climate change considerations into natural resource management. The purpose of the framework is to help land managers understand potential impacts and integrate climate change into their planning and management, closing the gap between the impacts of climate change research and natural resource management.

Predicting the effects of climate change on forest ecosystems and then coming up with and applying management solutions for adapting forests to future conditions is a major challenge. CCRF can be used for climate change response across a wide range of landscapes, including forestlands privately owned to federal-owned forestlands. It can also be modified to adapt to different locations and landscapes. Information components include partnerships, adaptation resources, vulnerability assessment, and adaptation demonstration projects.

The CCRF approach has six steps:

1. Identifying locations, ecosystems, and time frame.

2. Building partnerships.

3. Assessing the ecosystem’s vulnerabilities including both exciting and new information from managers and scientists.

4. Compiling adaptation approaches and strategies: To develop a menu of more targeted adaptation methods and approaches relevant to regional land managers, broad adaptation strategies are to be examined within the context of the project area.

5. Planning and implementing appropriate scales: Coming up with diverse alternative adaptation tactics.

6. Integrating monitoring and evaluating the effectiveness of the framework.

The CCRF has been implemented in several locations in the US through coordinated localized projects in various eastern US regions, including Mid-Atlantic, the Central Appalachians, Central Hardwoods, Northwoods, New England, and Urban Forests.

Aqueduct

Aqueduct's tools use open-source, peer reviewed data to map water risks such as floods, droughts, and stress. Beyond the tools, the Aqueduct team works one-on-one with companies, governments, and research partners through the Aqueduct Alliance to help advance best practices in water resource management and enable sustainable growth in a water-constrained world.

This adaptation tool includes:

1. *Aqueduct Water Risk Atlas* which maps and analyses current and future water risks across locations.

2. *Aqueduct Country Rankings* which allow decision makers to understand and compare national and subnational water risks.

3. *Aqueduct Food* which identifies current and future water risks to agriculture and food security.

4. *Aqueduct Floods* which identifies coastal and riverine flood risks and analyses the costs and benefits of investing in flood protection.

Ecosystem-Based Management Tools Network

The Ecosystem-Based Management (EBM) Tools Network is a platform coordinated by NatureServe and Open Communications for the Oceans (OCTO) that provides a premier source of information about EMB tools. The EBM tools are methods and software that help integrate ecosystem-based management (EBM) principles by incorporating scientific and socio-economic information into decision-making.

The EBM Tools Network offers a range of resources and support for conducting ecosystem-based management of coastal marine systems. It brings together EBM tools developers and training providers. It also has a database that helps users to find or share information about decision support tools for coastal marine spatial planning and ecosystem-based management. The database can easily be searched and accessed. The users can also access webinars, training, and expert advice on the software tools and methods.

EBM tools can help develop models of ecosystems, generate scenarios illustrating the consequences of different management decisions on natural resources and the economy, and facilitate stakeholder involvement in planning processes.

The EBM tools that the network focuses on are for:

- Assessing climate change vulnerability and adaptation planning.
- Ecosystem-based coastal and marine spatial planning.

- Minimizing land use impacts on the coastal and marine environment through integrated land-sea planning.

NatureServe Vista

NatureServe Vista is a software analysis tool developed and managed by the NatureServe organization. The tool is an extension of ArcGIS. It supports assessment and planning in land and water management. NatureServe Vista aids in developing conservation strategies related to habitat management and land use.

The NatureServe Vista software can analyse the ecological conditions of target areas. The tool combines stakeholder values, expert knowledge, and data and values to support well-documented and defensible solutions.

The core objective of NatureServe Vista is to offer a systematic methodology for conservation planning and decision-making through the analysis of environmental data, enabling users to predict the impacts of land use changes and aiding in the development of conservation strategies. The tool also helps planners to understand the local ecological systems and identify high-priority land and water systems for conservation and evaluate the land use plans. Target users include land managers, conservation organizations, government agencies, and researchers.

How it works

The NatureServe software requires one to load the data for analysis. The data may include information on land cover, species distribution, and habitat characteristics. A wide range of pre-built ecological models are applied to this data for the analysis of land use and landscape and how any changes can affect the habitat and species distribution. The choice of an ecological model to apply depends on factors such as the species of interest or the aim of conservation. ArcGIS allows for spatial analysis of the data through the creation of overlays and to generate spatial statistics.

The software also provides scenario analysis and outputs, which enables the simulation and analysis of different land use scenarios by adjusting variables such as conservation measures, habitat quality, and land cover to gauge the potential outcome of different conservation strategies. The output can be visualized through the creation of maps reports and presentations, and users can utilize the site explore functions for further analysis of different sites in the data.

NatureServe Vista has been applied in conservation and planning projects such as in the US Fish and Wildlife Service for refuge vulnerability and analysis and in various counties in Georgia for coastal analysis about sea level rise.

Spatial Trends in Coastal Socioeconomics (STICS)

Spatial Trends in Coastal Socioeconomics (STICS) is a map-based website that provides georeferenced and time-based demographic data from the US Census Bureau and the Bureau of Economic Analysis. The website compiles data for estimating attributes in several coastal management jurisdictions. Analyses of these data can reveal socio-economic trends of the coastal regions in the country, such as watersheds, estuaries, floodplains, counties, and states.

Understanding these spatial patterns and dynamics in coastal socioeconomics is crucial for effective coastal management and sustainable development. The policymakers, planners, and stakeholders use this information to make informed decisions regarding land use planning, infrastructure development, disaster risk reduction, and social equity in coastal regions.

Spatial Trends in Coastal Socioeconomics focus on understanding how human populations and economic activities are distributed and interact in coastal regions and its features include the following:

- Population distribution in the coastal areas
- Economic activities, such as fishing, tourism

- Urbanization and land-use

Spatial Trends in Coastal Socioeconomics involve studying patterns of urban expansion, land use changes, and their impacts on the environment and coastal ecosystems. It focuses on understanding the vulnerability of coastal communities to hazards like storms, hurricanes, and sea-level rise. It involves analysing the location of vulnerable populations, infrastructure, and economic assets in coastal zones and assessing their exposure and susceptibility to hazards. Social inequalities include studying the distribution of wealth, access to services and resources, and the impact of socio-economic factors on the well-being of coastal populations.

Analysis of spatial trends in coastal social economics involves:

- Identifying vulnerable areas along the coast through a spatial analysis involving mapping factors such as sea-level rise, coastal erosion, storm surge zones, and flood-prone areas.
- Assessing socio-economic risks associated with climate change impacts. It helps analyse the spatial distribution of important social and economic assets for appropriate mitigation strategies.
- Mapping social vulnerability as spatial analysis allows for the mapping of social vulnerability in coastal areas through finding factors like education, income level, and social networks, which helps to identify the specific areas for action.
- Identifying adaptive capacity. Spatial analysis helps to identify areas with existing adaptive capacity in terms of infrastructure, socio-economic conditions, and institutional support.
- Identifying opportunities for coastal resilience such as restoration of coastal ecosystems.

Spatial Trends in Coastal Socioeconomics provides spatially explicit information on vulnerability, social equity, adaptive capacity, and potential for strengthening coastal resilience, making them a useful tool for planning climate adaptation. It helps decision makers to prioritize adaptation measures and make well-informed decisions, to ensure the long-term sustainability and climate change resilience of coastal areas.

4.1.6 Knowledge exchange platforms

weADAPT

The weADAPT tool was developed and is managed by the Stockholm Environment Institute (SEI) as an open-source online space for climate change adaptation issues. It allows policymakers and researchers to access reliable, high-quality information and connect through sharing experiences and lessons. weADAPT's technical development and content curation is based on significant consultation and teamwork between the weADAPT team and a network of knowledge partners, including OXFAM, IIED, Climate and Development Knowledge Network (CDKN), National Adaptation Plan (NAP) Global Network, and Climate Knowledge Brokers.

The platform was designed to share knowledge in a way that is intelligent and personalized; it appends links and incorporates all the relevant knowledge collected. Sharing case studies, reports, and journal articles on weADAPT creates an opportunity for anyone interested in climate change adaptation to interact, including potential donors.

The tools facilitating sharing of information on weADAPT are:

- Adaptation layer: This is an interface of Google Earth that supports map generation.
- Knowledge base: This is where multiple articles and topics relating to climate adaptation are hosted.
- Climate Adaptation Options Explorer: This is a decision support tool for screening adaptation alternatives, then providing guidance in selecting the most appropriate and sustainable option.

- Climate Information portal: This provides and visualizes historical climate data and a range of forecasted future climate data from multiple climate models and guides users through interpretation.

Members create profile descriptions that include information about their profession, interests, and publications, connecting easily to others with similar interests. weADAPT also includes the Adaptation Layer map of case studies that help identify where, who, and what is being done in the field of climate change adaptation and variability. It allows users to search for case studies and projects based on geographic location using themes and networks. It covers 22 diverse themes. Some themes include climate, food security and agriculture, vulnerability, human mobility, adaptation decision-making, and using climate Information.

Climate Adaptation Knowledge Exchange (CAKE)

The Climate Adaptation Knowledge Exchange (CAKE) is a knowledge sharing platform managed by EcoAdapt, which is a non-profit organization that aims to build a resilient future in the face of climate change by bringing together a wide range of players to reshape planning and management in response to quick climate change.

The website was launched in July 2010 and provides a platform for knowledge sharing of high-quality climate change adaptation case studies and relevant tools for assessment, planning, implementation, evaluation, and monitoring.
The platform also hosts community forums where users can share their experiences and learn from others. Managers, planners, and anyone else interested can take more informed actions by leveraging resources submitted by users and EcoAdapt staff. CAKE provides resources for all knowledge levels and features information spanning geographies, sectors, and scales.

Characteristics of the case studies presented:

- Relevant to conservation and resource management within the context of climate change.
- They support climate change adaptation.
- Clear on actual or planning process, implementation, and outcomes of adaptation initiatives.

CAKE is user-friendly, joining is free, and registration is required by filling out a user form for you to contribute. Exploring and downloading resources like case studies does not require registration.

Climate Change Knowledge Portal (CCKP)

The Climate Change Knowledge Portal (CCKP) serves as the central source of climate-related information, data, and tools for the World Bank Group. It offers an online platform that enables users to access and analyse extensive data pertaining to climate change and its impact on development. The portal currently provides climate data at national, subnational, and watershed levels. To effectively incorporate scientific information into decision-making processes, it is crucial to have adaptable frameworks, relevant data, and informative tools that can furnish comprehensive information to a diverse range of users. This allows them to utilize scientific insights when designing projects or policies.

The CCKP is an online platform designed to improve comprehension of climate change by offering information at various levels of complexity. By utilizing up-to-date climate data and scientific research, the CCKP equips development practitioners with valuable resources to investigate, assess, consolidate, and acquire knowledge about future climate scenarios, projected risks, and vulnerabilities related to climate change. It encompasses datasets related to climate, disaster risk, and socio-economic factors, along with synthesized products like Climate Risk Country Profiles that are specifically tailored for users in particular countries or sectors. Additionally, the portal includes smart links to other resources and tools for further exploration.

Adaptation Community Platform

The Adaptation Community Platform was developed for the interested public and adaptation experts to provide information on applying approaches, methods and tools that facilitate the planning and implementation of adaptation action. Enhancing knowledge and sharing experience is the key to successful adaptation strategies. Therefore, this platform offers a wealth of information, online sessions, and training on nine key topics along the comprehensive risk management approach. These topics include:

- *Climate services (CS) provide decision makers with customized ready-to-use climate information and products (forecasts or historical trends) to effectively manage climate risk.*
- *As the negative impacts of climate change are expected to intensify in the near future, Comprehensive climate risk management (CRM) aims at averting, minimizing and addressing loss and damage.*
- *The national adaptation plan (NAP) process aims to integrate adaptation into development planning and to reduce vulnerability to climate change. As the primary national planning process for adaptation, it can support the implementation of NDC adaptation goals.*
- *Mainstreaming of adaptation systemically includes climate risk and adaptation considerations in decision-making and planning processes.*
- *Ecosystem-based adaptation (EbA) is the sustainable use of biodiversity and ecosystems to help people adapt to the adverse effects of climate change.*
- *Agroecology aims at transforming agricultural and food systems towards climate resilience and adaptiveness in order to achieve food security for all.*
- *Climate change and migration looks at how extreme weather events and gradual changes impact human mobility: migration, (disaster) displacement, as well as planned relocation.*
- *Private sector and adaptation respond to climate-related economical risks and seizes business opportunities in order to safeguard operations, to strategically create sustainable growth and to increase societal resilience.*
- *Monitoring and evaluation (M&E) helps keep track of the implementation of adaptation measures and evaluates their effectiveness and outcomes. The Paris Agreement encourages 'M&E and learning from adaptation plans, policies, programmes and actions' (Article 7.9d).*

CommunityViz

CommunityViz is an online platform developed by the Orton Family Foundation in partnership with Placeways, LLC. As an extension of ArcGIS, it provides users with the capability to export and view their work on various platforms, including ArcGIS Online, Google Earth, and other Keyhole Markup Language (KML)/KMZ viewers such as ArcGIS Explorer, which allows for seamless integration and visualization of the work done in CommunityViz within these commonly used mapping and geospatial tools.

CommunityViz has two components for 3D visualization of spatial data, Scenario360 and Scenario3D. Scenario 360 offers users the ability to design and explore hypothetical scenarios, assess the impacts of proposed changes, and integrate with three-dimensional visualization tools like Google Earth. On the other hand, Scenario 3D facilitates the visualization of potential land use changes and scenarios in an interactive three-dimensional format. This functionality serves as a valuable visual tool for effectively communicating the potential impacts of different land use decisions.

CommunityViz has several notable features, including:

- *Scenario planning.* Users can create and compare multiple land-use plans simultaneously, enabling the study of alternative scenarios.

- *Dynamic analysis updates.* When changes are made to a plan, CommunityViz automatically recalculates the associated impacts, ensuring that the analysis stays up to date.
- *3D modeling options.* CommunityViz provides three choices for 3D modeling, including the ability to export data to Google Earth for visualization purposes.
- *Wizard-driven tools.* The software includes user-friendly, step-by-step tools that guide users through the creation of common planning analyses, such as build-out analysis and suitability analysis.
- *Custom model and analysis creation.* CommunityViz offers advanced tools for users to develop and customize their own models and analyses, providing flexibility and the ability to address specific planning needs.

CommunityViz can facilitate effective decision-making processes and planning in forest management planning, natural hazard risk assessment, evaluation of habitat fragmentation, and water quality management. The versatility of Scenario 360 allows it to support a wide range of planning and analysis tasks, including those specific to climate change adaptation and mitigation.

CommunityViz also has various features specifically designed to enhance public participation and facilitate collaboration in the decision-making process related to land use. These features aim to engage the public, gather input, and encourage collaborative decision-making among stakeholders involved in land-use planning. Target users include national, regional, and local government planners and private design and planning companies.

Digital Coast

Managed by the National Oceanic and Atmospheric Administration (NOAA), Digital Coast is an online tool that brings together critical information on coastal regions under one site. The website has proved beneficial in aiding its users in policy formulation, planning adaptation strategies, and steps to mitigate the negative consequences of climate change. Digital Coast is a hub for information to tackle challenges affecting coastal areas, such as climate change, coastal ecosystem preservation, land utilization, and hazard prevention. The website provides up-to-date data that is publicly available and accessed through web search.

Many organizations contribute to this website. The data from different resources, such as private organizations, academic institutions, and public entities are vetted to ensure quality and reliability. The users can, therefore, find verified information that is critical to the management of coastal resources. The resources on this website help users identify climate change-associated risks in the coastal regions and provide training and tools for mitigation strategies. Target users include coastal planners and managers, researchers, and academic institutions.

The Digital Coast website provides a diverse range of resources that can be accessed through the following sections on the site:

- *Data and maps:* This section gives the users access to a collection of coastal data such as the marine ecosystem, habitats, risks and vulnerabilities in these regions, ocean data, and geospatial information. Maps aid in data visualization and give an overview of the coastal regions.
- *Tools:* In this section, you can find tools that help with visualization and analysis, such as sea-level rise viewer and inundation tools. Currently, there are 82 tools on the site, and users can find the desired tools by searching using keywords for easy filtering. The available interactive tools are designed to support coastal decision-making and planning.
- *Training:* The training section of the Digital Coast website provides a comprehensive selection of educational resources and courses specifically designed to improve knowledge and skills in coastal management. This section offers a variety of learning opportunities, including tutorials, manuals, workshops, and webinars.
- *Resources:* This section includes references for the data used on the website and provides additional materials

for the coastal managers, such as case studies and publications, which act as guidelines for obtaining more information on coastal areas.

Google Mashup

Google Mashup is an online service tool managed by Google, which allows for the combination of different web pages and data into one to offer a new service or application displayed in a single graphical image. Users can utilize sources such as Google maps and other Google services to mash up with custom data to create a personal Google map. Google integrates tools such as API to generate Google maps API that can provide a basis for overlays, allowing the users to combine additional data to the maps.

Google Mashup allows users to import climate change data into google earth and google maps to create downloadable datasets which can be used by a range of geospatial applications and overtime to cover topics such as climate projections, fire hazards, land cover, and habitat, population projections, and sea level rise in the bay area among others. Many mashups have been created to that effect, including ones that show the rate of sea level rise and provide temperature, precipitation, and sunshine information by region.

Steps for using Google Mashup

Step 1: Identify credible climate data sources such as precipitation information, temperature records over time, and sea-level rise records.

Step 2: Extract and process this data to ensure it is in a transferable format, such as a CSV file, in preparation for creating a Google Mashup.

Step 3: Integration of this data into Google Mashup, which involves the use of Google Maps API to embed the data into maps for visualization. The user can also overlay this data by plotting data points such as heat maps and polygons to act as variables for visualization. Additional features such as filters can be incorporated to help in a detailed view and analysis of the climate change data in a selected map region.

Using Google Maps and climate data, Google Mashup can create a visualization of the climate change data and show the trends as well as the anticipated climate change impacts on different areas. The information generated can be used to create awareness and help in the development of mitigation and coping strategies. The creation of climate change Google Mashup requires relevant skills and access to accurate and reliable climate information.

Mashups can provide decision support tools in the study of the impacts of climate change and variability on health and enhance the development of more effective adaptation strategies. Mashups that use Google Earth and Maps may offer improved data linkages between climate, weather, and environmental data with other health and well-being databases and expand access to these linked data. Additionally, data linkages provided by environmental-health Mashups could explore currently hypothetical but unproven associations between climate and health, such as climate change, harmful algal blooms, and human health effects. Also, mashups may identify hotspot locations and points in time with convergent increased environmental and human health risks to vulnerable populations. This information can foster resilience and adaptive capacities for individuals, households, communities, and regions to the health and well-being impacts of climate change by scaling up adaptation strategies of proven effectiveness.

4.1.7 Climate-smart agriculture and adaptation interventions prioritization tools and frameworks

Climate-Smart Agriculture Prioritization Framework (CSA-PF)

The Climate-Smart Agriculture Prioritization Framework (CSA-PF) is a multidimensional tool that was developed by the International Center for Tropical Agriculture (CIAT) and CCAFS. The tool helps in determining the best ways to prioritize adaptation options and allocate resources among various alternatives in different value chains. The economic feasibility of these practices is evaluated using cost-benefit analysis (CBA) to create a portfolio of viable and cost-effective options. The tool has been applied in several countries in sub-Saharan Africa. The CSA-PF tool offers a detailed, step-by-step process to assist stakeholders in narrowing down a large array of climate-smart agriculture (CSA) practices to a more manageable and feasible portfolio of options. By employing the CSA-PF tool, the researchers are able to streamline the identification and selection of the most viable CSA practices for smallholder farmers and value chains in sub-Saharan Africa.

The CSA-PF tool follows the following steps:

The first step involves identifying both the ongoing and promising practices related to the scope and stage of the value chain.

The second step includes selecting the two most promising practices at each step of the value chain (input purchase, production, post-harvest, and marketing). This is dependent on a selected criterion, for instance, the severity of climate hazards such as floods or droughts.

The third step is the ranking of the selected CSA practices by order of importance. The criteria for the selection include the practice life cycle, impact on productivity, building resilience, and mitigation benefits.

Finally, a comprehensive CBA is conducted to evaluate the economic viability of the prioritized CSA practices. The aim is to achieve economic efficiency and provide reliable information for value chain stakeholders to make rational decisions.

Climate-smart agriculture rapid appraisal (CSA-RA)

Approaches that aim to identify and prioritize locally appropriate climate-smart agriculture (CSA) technologies will need to address the context-specific multidimensional complexity in agricultural systems. The climate-smart agriculture rapid appraisal (CSA-RA) is a mixed method approach that draws on participatory bottom-up, qualitative, and quantitative tools to assess the heterogeneity of local contexts and prioritize context-specific CSA options (Mwongera et al. 2017). The CSA-RA is designed to assess biophysical, sociocultural, economic, and technological characteristics at the household, farm, and community/regional level. The CSA-RA employs gender-disaggregated methods, including gender differences in perceptions of climate change and its impacts. The CSA-RA combines common participatory rural appraisal (PRA) and rapid rural appraisal (RRA) tools into one methodology that disaggregates the gender dimension and includes resource mapping, climate calendars, historical calendars, cropping calendars, organization mapping, transect walks, key informant interviews, farmer interviews, and pairwise ranking matrix. The tool collects qualitative and quantitative data from various stakeholders (farmers, local leaders, researchers, local-level agricultural experts, private sector actors, donor organizations, and policy implementers), allowing expansive analysis, triangulation, and validation.

The main components of the CSA-RA tool include:

Cropping calendar: The cropping calendar has two main objectives. First, it is used to identify main crops, crop sequences, and when associated production activities take place. Second it is used to identify the gender division of labour and how access to and control of resources varies for men, women, and children.

Organizational mapping: Venn diagrams are used in mapping the rural organizations utilized by farmers. The participants rank each in terms of its relative importance and illustrate linkages between different organizations, such as no linkages with other organizations, some linkages, and a lot of co-operation. This is important to identify capacity building needs, key actors that may influence the agricultural practices of the households and for outscaling CSA.

Resource mapping: The objective of the resource mapping is for communities to delineate agroecological zones and show the distribution of resources in the community, for example forests, pasture, rivers, water sources, human settlement, and infrastructure. This exercise is conducted by first having a general discussion of the different agro-ecological zones in the community, then the participants are self-organized into the groups by agroecological zone and then each group is further disaggregated into groups based on social identity as appropriate in the context (for example by gender, ethnicity, age, etc.). This exercise is followed by a discussion to provide insights on changes in the resources over time and can then be used to develop community action plans and identify future investments.

Climate calendar: The climate calendar is used to identify typical and abnormal weather patterns (e.g., extreme wet and dry years), periods of stresses and vulnerability and to discuss farmer perceptions of the overall impact of climate variability on agricultural production. In small groups organized by gender, participants first discuss a typical year and identify the rainy months and dry months. Then participants are asked to identify an abnormally wet year. This year is written down and the process of identifying in which months it rained and which it did not is repeated. Finally, participants repeat this process for an abnormally dry year. This provides an opportunity to analyse and understand the impacts of normal and extreme conditions, and how farmers have coped with such variability in rainfall.

Historical calendar: The historical calendar is used to show how the community perceives changes in climate (rain, temperature); natural resources (soil, water, trees); and agricultural activities (crop production, cultivated area, livestock) over time, and what might have been the driver for these changes. Participants organized by gender are asked to rank the different aspects over the last several years (depending on maximum age of participants). A scale of 1-to-5 is used, where 1 is very low and 5 is very high.

Transect walks: Transect walks are conducted to identify the community's landmarks, soil and vegetation patterns, socio-economic indicators, agriculture practices, biodiversity, and resource endowments. The route to follow on the walk is selected randomly within the study site. The walk also includes visits to randomly selected farms and discussions with farmers. The transect walks provide a basis for validating information received through individual interviews and/or group discussions.

Key informant and farmer interviews: There are conducted using semi-structured interviews and include modules on farming systems, local organizations and their roles, gender dynamics, household characteristics, agriculture practices, land tenure, climate risks, agricultural production challenges, market access, credit access, input use, pest and diseases, and seed supply.

Pair-wise ranking: Pairwise ranking combines both the ability to compare and to rank categories. The group is divided by gender and by agro-ecological zone (from the resource mapping exercise). Group participants then list all agriculture practices that they are aware of. Facilitators retain practices from the group list that qualify as CSA practices, based on literature sources (such as the FAO CSA source book; FAO 2013). Researchers can also complement this list with other CSA practices that have been identified as particularly relevant for the site (i.e., during key informant interviews or practices that are being promoted by government or NGOs in the region). The participants are asked to consider one pair of practices at a time and for each pair of practices, consensus-oriented discussion is used to determine which of the two practices is preferred until the matrix is completed. A count is taken of the number of times each practice appears in the matrix. Practices are ranked by the total number of times they appear in the matrix.

Engaging with stakeholders: The CSA-RA engages with multiple stakeholders, (e.g., farmers, local leaders, researchers, local-level agricultural experts, district-level extension agents, private sector, donor organizations, and policy implementers) both individually, and in socially differentiated groups.

Quantitative data collection and analysis: Data collected during farmer interviews is used to perform economic analysis to understand returns to major farm enterprises and to construct a well-being and asset index.

The CSA-RA tool has been applied in Uganda and Tanzania.

Participatory Social Return on Investment (PSROI)

Participatory Social Return on Investment (PSROI) is a framework that builds on social return on investment (SROI), a methodology developed by Roberts Enterprise Development Fund (REDF). The PSROI framework requires the participation of stakeholders in planning, decision-making, valuation, and validation of adaptation process. It is a participatory method for establishing economic, social, and environmental costs and benefits of prioritized intervention in adaptation planning.

The PSROI steps are:

Step1–Identify key stakeholders: Involves identifying and selecting stakeholders who will participate in the planning and costing process. The PSROI leader should conduct a stakeholder analysis to capture a broad and relevant representation of the identified stakeholders to contribute to the adaptation selection and costing process. The process should be transparent and inclusive.

Step 2–Identify challenges and prioritize adaptation strategies: A diagnostic participatory workshop is organized. The workshop participants should map the local values and norms and identify key environmental challenges, risks, and past responses. The stakeholders should select adaptation themes that have the highest potential and develop adaptation plans and actions.

Step 3–Design interventions: The adaptation plans and theme are developed further into specific adaptation intervention by incorporating the technical design in consultation with local partners or experts to facilitate Step 4 (cost-benefit analysis). At this stage, the capacity of the intervention to address future climatic shocks or reduce climate risk is tested.

Step 4–Baseline cost-benefit analysis: The baseline cost-benefit valuation is undertaken using secondary data, literature, industry, and key informant data. PSROI ratio calculation for economic, social, and environmental impact is calculated. The cost of the intervention is subtracted from the benefit of the intervention to calculate the net present value (NPV) over a determined period.

Step 5–Validate baseline results: The final step involves the process of validating the PSROI framework by conducting semi-structured interviews with a representative sample of the study community. Comparison of the perceptions and values of the local stakeholders with the baseline PSROI leads to validation and discovery of new benefits and household-level data which can alternate the interpretation of assumptions realized in Step 4. The PSROI ration will be calculated from the primary data and compared with the baseline PSROI ratio.

The PSROI framework is an iterative process aimed at matching the needs of the stakeholders with the appropriate intervention. The process leads to a list of prioritized interventions appropriate to the current and future adaptation needs of the community.

Climate-Smart Agriculture Investment Plan (CSAIP) development guide: From concept to action

This guide offers a blueprint for developing a climate-smart agriculture investment plan (CSAIP). A CSAIP is a strategic and thorough planning document for proposing high-potential and high-suitability agricultural development projects. The process of creating a CSAIP leverages stakeholder engagement and capacity building by conducting a situation analysis, listing, and prioritizing potential CSA investments, and developing preliminary designs and guidance for implementing and monitoring project investments. The result is a suite of country-supported and scientifically vetted investments ready to present to potential investors.

Who is involved in CSAIP?

The CSAIP development team may be selected from within the country, contracted internationally or a combination of the two. Regardless, all CSAIP teams need an in-country facilitator to engage stakeholders, a group that includes key individuals from multiple sectors specializing in agriculture, rural development, climate change and planning. For example, stakeholders could include high-level representatives of government agencies and ministries, the private sector, relevant NGOs, farmer organizations and potential implementers and donors. Technical experts, extension workers, researchers, farmers, and academics are all crucial to ensure that the investments are practical and viable within the context. Such diverse representation helps ensure that investments are aligned with policy, organizational goals, and national priorities, and creates an authorizing environment for development of the CSAIP.

Phases of CSAIP

The guide has four phases:

Phase 1 entails situation analysis

Phase 2 focuses on prioritizing investments.

Phase 3 looks at the project concept.

Phase 4 concludes with identifying, monitoring, and evaluating elements.

Economics of Climate Adaptation (ECA)–Guidebook for practitioners

The Economics of Climate Adaptation (ECA) approach bridges this gap and offers a unique approach towards the flexible identification of cost-effective climate change adaptation (CCA) measures for a variety of projects and sectors. It addresses the following questions:

1. What is the potential climate-related damage over the coming decades?

2. How much of that damage can be averted, using what type of CCA measures?

3. What investments will be required to fund those measures–and will the benefits of these investments outweigh the costs?

ECA offers a systematic and transparent approach that fosters trust and initiates in-depth inter-sectoral stakeholder discussions. The methodology can be flexibly applied from the national level down to local level to different sectors and different hazards. It also gives guidance on what aspects to focus on during a feasibility study. It provides key information for program-based approaches, insurance approaches and has potential to support National Adaption Plans' (NAPs) development.

Why use ECA?

1. ECA helps estimate actual and future risks.
2. It is a multi-hazard approach.
3. It can help in estimating actual and future costs.
4. It can help in identifying and ranking potential CCA measures.
5. It defines potential climate change adaptation measures for investment purposes.
6. It enables multi-stakeholder collaboration and ensures local involvement to create a long-term adaptation strategy.
7. It creates a structure for a transparent approach towards climate adaptation.

4.1.8 Climate risk and vulnerability assessment tools and frameworks

Climate Change Vulnerability Index (CCVI)

The Climate Change Vulnerability Index (CCVI) is an online tool that aids in assessing the susceptibility of different areas to adverse climate change. Developed by global risks advisory firm Maplecroft, it incorporates social and ecological factors to identify areas likely to be affected by adverse weather changes such as drought and flooding.

It combines the interaction between the occurrence of extreme climate events and the ongoing shifts in climate patterns with the existing vulnerability of humans to those environmental pressures, as well as the country's ability to adjust and respond to the consequences of climate change. CCVI offers a consolidated numerical rating for evaluating the extent of exposure, sensitivity, and adaptive capacity to climate change, assisting businesses in assessing potential risks posed by future climate shifts.

CCVI empowers disaster managers and policymakers by enabling them to evaluate the relative vulnerability of populations and the relative significance of factors that contribute to such assessments. This capability allows users to prioritize their management strategies for adapting to climate change and develop actions that enhance the resilience of the human population in the face of climate change. By using the CCVI, managers can make informed decisions to protect and enhance the adaptive capacity of the human population, ultimately increasing their ability to withstand and thrive in a changing climate.

The Climate Change Vulnerability Index helps users to gain insight into the vulnerability of humans and species to risks associated with climate change. In addition, it is helpful in assessing and comparing specific locations within countries or regions using subnational data on climate-related risks. Target users include resilience officers, disaster managers, and control managers.

The evaluation process considers 42 factors related to social, economic, and environmental aspects to analyse the vulnerability of nations across three main areas.

1. Subjection to climate-related catastrophes.

2. Anticipated vulnerability, which is assessed by examining a country's governmental capacity and infrastructure to effectively address and mitigate the impacts of climate change.

3. Human responsiveness, which involves evaluating population patterns, availability of natural resources, dependence on agriculture, levels of development, and the presence of conflicts.

CCVI offers visualization of the data on a map, which shows the vulnerability of different areas at a specific site or a regional scale. The two most common map viewers provided by CCVI are heat and flood viewers. The tool can also combine the two maps, heat, and flood viewers, to create several vulnerability scenarios and help users to understand the concepts and effects of climate change on different areas. In addition to the two maps, CCVI also provides a viewer story map that guides the user through each content on how to navigate and print the maps for visualization. With the data, users can identify areas that are extremely vulnerable, moderately vulnerable, or less vulnerable to climate change.

Climate Change Sensitivity Database

The Climate Change Sensitivity Database was developed by the University of Washington, in partnership with the state and federal resource agencies and the Nature Conservancy in the Pacific Northwest. This website was designed to assess the impact of climate change on various ecological systems and species in the Pacific Northwest region. The climate sensitivity database also considers the degree of vulnerability of the Pacific Northwest region species by assessing their exposure to adverse climate change effects. It allows for the examination of potential consequences of climate change across various landscape levels.

The sensitivity database covers various areas such as Idaho, Oregon, and Washington. It involves the collective efforts of individuals involved in the preservation and management of natural resources, such as conservation planners, natural resource managers, and scientists. The data obtained from this database on the sensitivity of different species provides critical information on the expected reaction of species to climate change and adaptability to changing environmental conditions. The users can find the various species on the website by searching the kingdom classification of the species, keywords, and landscape where the species are. Target users include researchers, conservation planners, and managers of natural resources.

The evaluation process has the following characteristics:

- The evaluation comprises four primary components: sensitivity database creation, case studies, species population, and habitat suitability modeling.
- The sensitivity database documents the susceptibility of various species and ecosystems to climate change and their adaptability to such changes. The case studies give specific and related examples on how different species are affected by climate change and their coping mechanism to such disruption in the environment.
- The species population modeling uses statistical models to evaluate changes in species populations over time, considering factors such as environmental changes.
- The habitat suitability modeling assesses the suitability of a species’ habitat in relation to changing environmental factors.

With the components of assessment, managers can apply the results in the management of species and landscapes, making the habitats suitable for the species in the face of climate change. Citing the data and case studies involved and the information gathered, conservation managers can also document adaptation and mitigation strategies for climate change.

Hazards US, Multi-Hazard (HAZUS-MH)

Hazards US, Multi-Hazard (HAZUS-MH) is a standardized tool developed by Federal Emergency Management Agency (FEMA) to estimate risk from floods, hurricanes, and earthquakes. HAZUS-MH software is downloadable and uses Esri's ArcGIS technology and other separate tools, such as the Comprehensive Data Management System (CDMS) to estimate the physical damage and social and economic impacts of disasters. It provides independent modules for data export and analysis, and reporting. The uses of the HAZUS-MH tool include:

- Mitigation by determining potential losses from disasters and identifying the most effective mitigation actions for minimizing those losses.
- Mapping and quantifying risk information on physical damage, economic loss, social impacts, and cost effectiveness of regular mitigation strategies.
- Used for real-time response efforts by estimating the impacts from storms or earthquakes sequences.

HAZUS-MH can collect data on statewide baseline inventories for properties such as buildings, essential facilities, and infrastructure. The tool can replace the inventory data latest information to update the data with more accurate data. However, adjusting these parameters and creating data inventories in locations outside US requires significant efforts.

Government planners, GIS specialists, and emergency managers have used HAZUS-MH for mitigation, recovery, preparedness, and response. Emergency managers use the HAZUS-MH maps templates to support rapid impact assessment and disaster response. In a regional approach, public agencies in the US and Canada collaborated by using the tool to determine the potential impact natural disasters across the Pacific Northwest. Communities have used HAZUS-MH, particularly in support of risk assessments that perform economic loss scenarios for a natural disaster. Other communities have used it to increase hazard awareness among in the community.

HAZUS-MH steps of analysis include:

Step 1: Analyse physical landscape.

Step 2: Identify hazards.

Step 3: Consider what is at risk.

Step 4: Analyse social and economic impacts.

Step 5: Produce maps, tables, and reports.

Social Vulnerability Index (SoVI)

Social Vulnerability Index (SoVI) is a tool developed by the Hazards Vulnerability and Resilience Institute at the University of South Carolina to compare preparedness, impact, and recovery from hazards, based on community characteristics and sociodemographic conditions. SoVI is a method that relies on pragmatic data to assess and compare the social vulnerability of different locations. It provides a relative measure that allows us to examine and distinguish between places. One advantage of SoVI lies in its comparative approach and the visual depiction of data through maps. The maps clearly depict the unequal preparedness levels or response capacity across different areas. They also serve as valuable tools for identifying areas where resources and social programs can be utilized more efficiently to mitigate vulnerability before an event occurs.

In the US, SoVI has been incorporated into numerous hazard mitigation plans at the state and county levels, as well as in public health risk assessments and resilience initiatives. SoVI has also been used as a practical decision-making tool to assist states in distributing funds for post-disaster recovery. In specific cases, SoVI is combined with information on the impact of the disaster and unmet needs, resulting in a clear identification of priority areas for recovery efforts. This data-driven approach, which considers vulnerability, impact, and need, allows for the objective allocation of recovery resources, focusing on assisting the residents who have been most affected and have the least capacity to recover on their own.

SoVI allows users to accomplish the following:

- Compare social vulnerability levels among counties within their state and across the nation.
- Compare or monitor changes in social vulnerability over time.
- Assess the capacity of a census tract or county to handle losses and damage during a disaster.

Target users include emergency response planners and public health officials.

SoVI utilizes data from the US Census American Community Survey as a standard source to eliminate variations that may arise due to the use of data from different resources. The variables incorporated in the index are factors contributing to a community's decreased capacity to effectively prepare for, respond to, and recover from hazards. The input data is standardized using percentages, density functions, and per capita measures.

To ensure the accuracy of the dataset, descriptive statistics, such as minimum and maximum values, standard deviation, and mean, are utilized to identify any data entry errors or missing values, which helps to maintain the integrity and reliability of the data used in the SoVI analysis.

The variables are standardized into principal components analysis (PCA). The output from PCA is used to assess the representation of social vulnerability across different locations.

As a comparative metric, SoVI is essential for practitioners and policymakers to identify counties that are less prepared in the face of disaster and aid in the preparedness and recovery steps. The variables are scored for each county and visualized using maps and compared to all other communities at the same level. SoVI has been successfully used in the US to prepare communities for the adverse effects of natural disasters.

System for Assessing the Vulnerability of Species to Climate Change (SAVS)

The System for Assessing the Vulnerability of Species to Climate Change (SAVS) is an online interface developed by the USDA. The SAVS is specifically created for managers to evaluate the comparative risk of different terrestrial vertebrate species experiencing population declines due to anticipated climate changes and associated factors. It is a user-friendly and adaptable tool, and it utilizes the readily available online questionnaire that incorporates predictive factors to assign scores indicating the vulnerability or adaptability of terrestrial vertebrate species to climate change. Along with the scoring matrix, the tool offers resources to facilitate the calculation of scores and the assessment of uncertainties.

SAVS also provides comprehensive instructions on how to score a species, the guidelines for applying the tool, a glossary of terms, and a discussion on how to utilize the scores for vulnerability assessments.

Vulnerability assessments and evaluations of extinction risk aid in identifying specific targets and prioritizing conservation efforts. By conducting these assessments, managers can determine the most crucial areas requiring conservation actions or adaptation strategies. The assessments help identify how ecosystems and species are affected by the projected changes in climate and use that information to develop new management and response protocols. Target users include species managers, local, regional, and national conservation managers, local, regional, and national conservation planners, and conservation planners.

Steps of SAVS

SAVS utilizes an online questionnaire with 22 questions to predict the vulnerability/ species population response to climate change. This questionnaire serves as a structured framework for evaluating the vulnerability or resilience of species to climate change. They are multiple-choice questions organized into four categories based on different themes: habitat, physiology, biotic interactions, and phenology.

Users need information from various sources, such as expert consultation, published materials, or personal knowledge, to complete the questionnaire. Before scoring, the anticipated changes in vegetation, climate, and disturbances specific to the region under consideration are characterized. This information will provide a foundation for understanding the potential impacts on species and their habitats, enabling a more accurate assessment of vulnerability.

The questionnaire in SAVS assigns scores within each of the four categories: habitat, physiology, biotic interactions, and phenology. These scores enable the identification of the primary sources contributing to the vulnerability of species. SAVS generates an overall score that ranges from -20 (indicating the highest level of resilience) to +20 (representing the highest level of vulnerability). Additionally, scores are provided for each of the four themes, ranging from -5 to +5. The overall scores rank the species based on their vulnerabilities. The categorical scores offer insights into the specific aspects of a species, such as habitat, that are particularly sensitive to future climate conditions or changes.

Uncertainty is accounted for in the assessment process by calculating the percentage of questions with insufficient or inconsistent information. This uncertainty value is associated with the overall and categorical vulnerability scores. Species with high uncertainty values may indicate the need for additional monitoring or research efforts to better understand their vulnerability to climate change. This information aids in understanding the key factors driving species declines and assists in formulating targeted conservation strategies.

Climate Vulnerability and Capacity Analysis Framework (CVCA)

Developed by the Cooperative for Assistance and Relief Everywhere (CARE), the Climate Vulnerability and Capacity Analysis (CVCA) framework assists in collecting and evaluating data on various communities to determine their ability to adjust to the effects of climate change and identify measures that can be taken to enhance their resilience. CVCA prioritizes the understanding of climate change risks, impacts, and adaptation at the community level. It is a participatory framework that promotes discussions between the local communities, governments, and other stakeholders. This framework focuses on climate change hazards and risks, the vulnerability of selected populations to these adverse changes, and the resilience of communities to the climate change risks and their adaptations to such.

The primary goals of the CVCA are:

1. To evaluate the susceptibility and adaptive capacity of communities at the local level through collecting, organizing, and examining the data at an individual, household, and community level to determine their vulnerability and preparedness to climate change. It also offers instructions and tools essential for conducting participatory research, and data analysis. CVCA considers the influence of local and national institutions and policies in facilitating adaptation efforts.

2. To integrate community knowledge with scientific data to gain a deeper understanding of the localized impacts of climate change through rigorous information gathering and analysis which fosters a local understanding of climate-related issues and pertinent adaptation strategies. The related discussions create opportunities to connect community knowledge with the existing scientific data on climate change.

The process of the CVCA tool involves the selection of the target area for the study, the definition of the scope of analysis, and the stakeholders involved in the study, such as individuals, households, community groups, and government institutions. The CVCA process has been developed as a systematic seven-step approach:

1. Defining the objectives of the study and the scope of the analysis.
2. Getting organized for the study.
3. Gathering any background or secondary information on the selected community.
4. Conducting a participatory study.
5. Collecting relevant information on the vulnerability of communities and adaptability.
6. Analysing the data obtained.
7. Validating and documenting the information/analysis to aid in policy formulation and mitigation steps in areas most vulnerable.

The CVCA suggests gathering information across various topics including climate conditions which involve assessing the local climate conditions; the trends in past climate patterns; forecast changes in temperature and adverse weather events; the impacts of unpredictable effects of climate changes and the risks associated with such; and socio-economic conditions and the livelihoods of the communities, which link the dependency of these activities to natural resources and their disruption by any climate changes. Lastly, CVCS also has a plan of action which aims at coming up with suggestions and ideas from the community on strategies applicable in adaptation and strengthening the resilience of local communities in the face of climate changes and extreme catastrophic events.

By exploring these themes and collecting information under each category, the CVCA process aims to provide a comprehensive understanding of the community's context, vulnerabilities, adaptive capacity, and potential pathways for the responsible government and local institutions to come up with mitigation steps for the target areas.

Climate Risk Screening and Management Tools

The tools facilitate assessing and addressing climate risks during the design of strategies, projects, and activities. Country and regional climate risk profiles and GHG emissions factsheets are also available to support this process. These tools are intended to be living documents that will be updated to incorporate feedback and learning as they are used to manage climate risk in strategies, projects, and activities. There are three main tools: the strategy tool, project tool and the activity tool.[2]

The tool navigation has the following steps:

1. Set up: consists of identifying what to screen, timeframes, geographies, and climate risks
2. Assess adaptive capacity: focusing on information capacity, social and institutional capacity, human capacity, and financial capacity.

2 More information about the tool can be accessed via this link: https://www.climatelinks.org/sites/default/files/2017-05-24_USAID-CRM-Tool-Strategy.pdf

3. Assign risk rating: based on characterization of climate risks and adaptive capacity, a qualitative risk rating is assigned: low, moderate, or high.

4. Identify opportunities: consider opportunities related to climate risk management and climate change mitigations.

5. Identify and select climate risk management options.

Participatory Assessment of Climate and Disaster Risk (PACDR)

The Participatory Assessment of Climate and Disaster Risk (PACDR) tool is designed to conduct community assessments of hazards, vulnerabilities, and local coping strategies in a participatory way. Its aim is to develop more effective and sustainable community adaptation strategies. The analysis is done together with local stakeholders in rural and urban communities.

Characteristics of PACDR:

Dynamic: Work in process, adaptable to different contexts.

Flexible: Modules can be used selectively or all together for an in-depth assessment.

Participatory: All stakeholders of a community are ideally represented in the assessment process to assure ownership and effective actions.

Easy: Easy to understand for community facilitators with basic skills in participatory rural appraisal (PRA) tools.

Well-tested: The tool has been used in various countries, cultures, and contexts.

Suitable for advocacy and lobby work: Several PACDR analyses in the same region/district are suitable as a factual basis to raise political awareness on climate and disaster risks, and to advocate for climate adaptation projects and climate finance.

A template on how to carry out a successful community-based climate and disaster risk analyses or a training workshop using the PACDR tool can be accessed here: https://pacdr.net/how-to-use-the-tool/

Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL)

The Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL) is a project planning web-based tool co-developed by four NGOs: International Institute for Sustainable Development (IISD), International Union for the Conservation of Nature (IUCN), Stockholm Environment Institute (SEI) and Helvetas Swiss Intercooperation. It is a desktop application that runs on Microsoft Windows. The user manual is accessible at: https://www.iisd.org/system/files/publications/cristal_user_manual_v5_2012.pdf.

CRiSTAL targets project planners and managers working at the local and community levels. However, other actors may also use the tool, including policymakers and decision makers. It helps users understand the links between a development project and its contribution to climate adaptation. CRiSTAL helps project planners and managers ensure that their project supports or does not constrain climate adaptation so that communities can achieve their development goals.

CRiSTAL helps users to understand:

i. How current and potential future climate hazards affect or may affect a project area and local livelihoods.

ii. How people respond to the current and potential future impacts of these climate hazards.

iii. Which livelihood resources are most affected by current climate hazards and which ones are most important for the response strategies.

iv. How project activities affect access to, or availability of, these critical livelihood resources.

v. What project adjustments (revision of existing activities and/or design of new activities) can be made to support climate adaptation and reduce climate risk.

CRiSTAL targets community-level development projects and is most useful at the planning stage, where specific project activities are designed. The process of climate change adaptation has four steps including assessing vulnerability and climate risks, identifying and prioritizing adaptation strategies, implementing adaptation strategies, and monitoring and evaluation of adaptation interventions. These compare well with the steps in the project cycle, demonstrating how adaptation can be integrated into development projects. CRiSTAL supports users most in the design of adaptation strategies. The tool can also help gather information on current and future risks and prepare users for the implementation stage. CRiSTAL relies on data collected through desk-based review, local stakeholder consultations, and expert interviews. Community consultations using participatory methods are useful in gathering information on local livelihoods and coping strategies.

CRiSTAL guides users through several analytical steps, which can be categorized into three phases:

Step 1: Understanding the livelihoods and climate context.

CRiSTAL enables the project planners identify how the community will be affected by climate, how they can respond to the climate impacts with the resources they have, what additional resources are required, and how they can build on the current condition for effective long-term response. The tool draws from the sustainable livelihoods framework and helps users focus on:

- Development issues and people's interests in the context of climate variability and change rather than seeing climate risk as an environmental problem.
- Opportunities rather than just constraints.
- People's access and control over resources, rather than just the presence or absence of resources.

The first phase, therefore, describes the livelihood and context and identifies and analyses climate risks. This phase generates a list of resources most affected by climate hazards and how to respond to the climate hazard.

Step 2: Evaluating the implications for the project.

Information on livelihoods and climate risks from Phase 1 helps to revise the project activities. A proposal of adjustments to prioritize activities that support climate adaptations will help identify opportunities and barriers to implementing the new project activities.

Step 3: Support monitoring and evaluation

The project planners and managers develop a monitoring and evaluation framework where adaptation outcomes are identified and monitored.

CRiSTAL users collect information through community consultations and discussions with other project stakeholders. Once users collect the necessary information, they enter it into the tool following a series of analytical steps that build on each other. At the end, users are provided with a systematic organization and presentation of:

- Livelihood resources that are most affected by climate hazards and most important for responding to climate impacts from the perspective of men, women, and different social groups.
- Proposed adjustments to existing projects and new activities to support climate adaptation.
- Desired adaptation outcomes and important influencing factors to be monitored.

Using this information, users can design and implement projects that safeguard and improve livelihoods in the face of climate risk.

Coastal Inundation Toolkit

The Coastal Inundation Toolkit is an online platform developed by Digital Coast Partnership of the National Oceanic and Atmospheric Administration (NOAA). The toolkit helps individuals to assess their vulnerability to coastal inundation, hence prepare for flooding by formulating mitigation adaptation and recovery plans. Its purpose is to guide communities in understanding their susceptibility to flooding and identifying appropriate measures to mitigate the associated risks. Moreover, it serves as a valuable tool for integrating the impacts of climate change into conservation planning. Climate change impacts, such as sea-level rise, can increase the risks caused by inundation. The Coastal Inundation Toolkit provides data on the susceptibility of different coastal regions helping users to predict the possibility of inundation in the event of adverse climate change.

The Coastal Inundation Toolkit enables its users to:

- Analyse the historical frequency of flood occurrences and peak water levels for most stations.
- Stay updated on water level conditions in real time along the trajectory of hurricanes and other coastal storms.
- Explore sea level trends and annual probabilities of exceeding certain water levels.
- Gain access to current water levels, 48-hour forecasts of water levels for specific regions, and historical data on flooding at a significant number of over 200 coastal water level stations.

Target users include disaster and resource planners and managers and community planners.

Methodology

The Coastal Inundation Toolkit displays a 48-hour forecast of the sea levels in the coastal regions, real-time data on the water levels, and past collected data on flooding in these areas. The toolkit also provides a visual representation of these data through maps and graphs. The maps come in two views: imagery and topographic view, where they provide vivid images of different coastal stations. They show areas that are experiencing or with the likelihood of experiencing extreme weather conditions, such as cyclones or hurricanes. The users obtain crucial data on sea pressure and wind speed for different regions by hovering over the maps. The graphs are plotted using data on the number of flooding or inundation events that have happened in a selected area over the years.

How to use the tool kit

There are five stages of information for effective utilization of the toolkit.

Step 1: Understanding coastal inundation provides knowledge and insights into coastal inundation, including its causes, impacts, and associated risk.

Step 2: Recognizing community risks and vulnerabilities, such as the challenges posed by flooding and the level of resilience of the communities.

Step 3: Generating maps to represent areas that are susceptible to inundation. The maps generated also portray the potential extent and depth of flooding, aiding in visualizing and planning for potential scenarios.

Step 4: Communicating the identified vulnerabilities and risks to the relevant groups, such as community members and important decision makers in the government.

Step 5: Exploring and emulating what other areas have implemented to address coastal inundation, which helps to improve collaboration between regions and knowledge transfer.

By organizing information and resources into these five stages, the tool enables users to systematically navigate and utilize the available resources for addressing coastal inundation effectively. The Coastal Inundation Toolkit assists decision makers and coastal residents to identify immediate risks, such as the imminent arrival of a hurricane, and long-term vulnerabilities including sea-level rise. In addition, the data obtained can help planners to prepare for any effects caused by inundation and predict the likelihood of flooding depending on the rise of the sea levels.

National Oceanic and Atmospheric Administration's Coastal Service Center (NOAA CSC) Roadmap

The National Oceanic and Atmospheric Administration's Coastal Service Center (NOAA's CSC) roadmap training provides a framework for state coastal managers and other participants to follow as they develop and implement climate change adaptation plans. It is designed to allow participants to foster dialogues on risks and vulnerability along coastal town centres and regional planning organizations. Coasts are particularly susceptible to climate change. They are already exposed to an array of social and environmental stressors. NOAA's CSC roadmap training allows actors to identify and characterize climate change phenomena such as rising sea levels, declining Great Lakes levels, and increased storm intensity/frequency.

NOAA's CSC roadmap allows actors to evaluate climate change and how its threats interact with other stressors and social and economic stressors. Actors assess community vulnerability to climate changes and threats and develop new strategies for risk mitigation. The NOAA's CSC roadmap training objectives for coastal communities include:

1. Defining community goals and identifying priority issues for consideration through the vulnerability assessment.

2. Addressing climate threats and climate change vulnerabilities through a comprehensive and rapid assessment of local community vulnerabilities.

3. Identifying commonalities and opportunities for coastal risk reduction and developing a regional action plan that includes milestones and achievements.

4. Developing partnerships and teams to integrate results from the risk matrix into existing or upcoming efforts.

Vulnerability assessment is integral in training and lays the foundation for climate adaptation strategy. It helps focus on the most vulnerable areas and the associated impacts that could cause the greatest loss. The vulnerability analysis process includes:

- Identifying the climate change phenomena.

- Identifying climate change impacts and consequences.
- Assessing physical characteristics and exposure.
- Considering adaptive capacities.
- Developing scenarios and simulating change, summarize vulnerability, and identify focus areas.

ThinkHazard!

ThinkHazard! was developed by the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR). The tool provides a general view of the hazards for a given location, that should be considered in project design and implementation to promote disaster and climate resilience (World Bank 2017). The tool highlights the likelihood of different natural hazards affecting project areas (very low, low, medium, and high), provides guidance on how to reduce the impact of these hazards, and where to find more information (World Bank 2017). The hazard levels provided are based on published hazard data, provided by a range of private, academic, and public organizations (World Bank 2017). This tool is a simple flagging system to highlight the hazards present in a project area. As such, a user is only required to enter their project location – national, provincial or district name. The results interface shows a user whether they require high, medium, or low awareness of each hazard when planning their project. ThinkHazard! also provides recommendations and guidance on how to reduce the risk from each hazard within the project area and provides links to additional resources such as country risk assessments, best practice guidance, additional websites. ThinkHazard! also highlights how each hazard may change in the future because of climate change.

The tool is accessible at: https://www.thinkhazard.org/en/. The method is documented at: https://gfdrr.github.io/thinkhazardmethods/.

Climate Risk Management in Agricultural Extension (CRMAE) Reference Guide

The Climate Risk Management in Agricultural Extension (CRMAE) Reference Guide is an accompaniment to the abridged CRMAE Handbook. Both the Reference Guide and Handbook are training and reference materials intended for use during implementation of the Climate Risk Management in Agricultural Extension course. The Reference Guide was designed for Ethiopia's subject matter specialists (SMS) and extension staff, including development agents (DAs). It may also be used by other actors, such as NGOs or community-based organizations (CBOs), who work closely with farmers and those who support them. It aims to provide foundational knowledge on climate and agricultural decision-making and practical tools to analyse climate-related risks, use appropriate weather and climate information to support agricultural decisions, communicate complex climate information effectively with farmers, and integrate climate services into agricultural extension activities.

Technical Guidance on Comprehensive Risk Assessment and Planning in the Context of Climate Change

The Technical Guidance on Comprehensive Risk Assessment and Planning in the Context of Climate Change provides orientation on how risks in the context of climate change can be comprehensively and systemically addressed through risk assessment. The guidance targets experts, decision makers, stakeholders and practitioners operating in the fields of disaster risk reduction (DRR) and climate change adaptation. It provides a framework and inspiration on how to apply comprehensive risk assessment and planning. The use and application of this guidance can be made context specific and customized, based on country realities. There are principles for a comprehensive approach for risk assessment and planning in the context of climate change including:

- Putting risk to human and ecological systems at the centre by considering risk as a value-based concept and considering the dynamic interaction among hazards, vulnerability, exposure, and underlying risk drivers when assessing risk and seeking solutions (risk reduction and adaptation).

- Fully accounting for the context of climate change by considering climate change as an underlying risk driver that modifies climate-related hazards, vulnerability, and exposure today and in the future. Also, consider current climate risk as well as future climate risk, insofar as they are relevant to their respective sectors and systems, and the decision-making and planning process to ensure adaptive planning and dealing with different timescales.
- Recognizing the complex and systemic nature of risks.
- Applying inclusive risk governance.
- Using multidisciplinary approaches to identify and select measures.
- Using the concept of risk tolerance.
- Addressing, minimizing and averting risks.
- Integrating risk across sectors and levels.
- Strengthening risk communication, information, and knowledge sources.
- Using iterative and flexible processes by considering.

Risk Stress Test Tool (RiST)

The Risk Stress Test (RiST) tool is an Excel-based tool developed to help conduct the stress testing analysis described in the methodological note Integrating Climate Change and Natural Disasters in the Economic Analysis of Projects: A disaster and climate risk stress methodology. The RiST tool has been designed to highlight risks to project outcomes over long time horizons, accounting for risks along three dimensions:

1. Changes in average climate conditions.
2. Impacts from natural disasters, with current frequency and intensity.
3. Changes in the frequency of natural disasters due to changes in average climate conditions.

The RiST methodology is linked to the World Bank's Resilience Rating System (RRS) and provides an approach to obtain an A rating for the resilience of a project, the first of two dimensions covered by the RRS.

Notre Dame Global Adaptation Initiative (ND-GAIN)

The Notre Dame Global Adaptation Initiative (ND-GAIN) summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead. The ND-GAIN Index is a project of the University of Notre Dame. The index looks at two key dimensions:

1. Vulnerability – a country's exposure, sensitivity, and capacity to adapt to the negative effects of climate change – by considering six life-supporting sectors: food, water, health, ecosystem service, human habitat, and infrastructure.

2. Readiness – a country's ability to leverage investments and convert them to adaptation actions – by considering three components: economic readiness, governance readiness and social readiness.

Platform for Agricultural Risk Management (PARM)

The Platform for Agricultural Risk Management (PARM) has the global mandate to contribute to sustainable agricultural growth, boost rural investment, reduce food insecurity, and improve resilience to climate and market shocks of poor rural households through a better management of risks.

The overall objective of PARM is to contribute to sustainable agricultural growth, reduce food insecurity, and improve the livelihoods of rural and poor farming households in developing countries. The specific objective of PARM is to strengthen agricultural risk management (ARM) in developing countries in a holistic and demand-driven basis by supporting partner countries in making ARM an institutional component of agricultural policy.

PARM approach

The PARM approach was first implemented in 2013. During the first phase which lasted until 2019, the objective was to mainstream agricultural risk management at global level and enable the integration of a holistic agricultural risk management into the policy planning and investment plans in sub-Saharan Africa countries.

The very positive results achieved by PARM during the first phase led to the development of PARM Horizon 2 (2019–2025). During Horizon 2, PARM is continuing to bring evidence and build capacities on agricultural risk management at global and country level, investing more resources in the design of ARM programs for investments, with a more structured involvement of public-private partnerships and in direct support to meso-level players (extension services, financial intermediaries, women's and youth's groups, NGOs, farmers' enterprises, and other organizations).

Caribbean Climate Online Risk and Adaptation tooL (CCORAL)

The Caribbean Climate Online Risk and Adaptation tooL (CCORAL) helps decision makers to see all kinds of activities through a 'climate' or 'climate change' lens, and to identify actions that minimize climate-related loss, take advantage of opportunities, and build climate-resilient development in their countries. It takes a pragmatic approach, promoting the right tools and techniques to fit the context of decision-making. It helps users undertake the following:

- Quick screening.
- Understand climate influence.
- Apply climate risk management process.

Using CCORAL can promote discussion of climate risk management amongst decision makers and lead to greater collaboration between experts and non-experts leading to decisions that are robust in the face of climate change.

4.1.9 Adaptation decision support tools and frameworks

Robust Adaptation Planning (RAP) framework

The Robust Adaptation Planning (RAP) framework is hosted by Oxford's Environmental Change Institute (ECI). It was developed as part of the Systemic Integrated Adaptation (SIA) project within the CCAFS and piloted in Ghana. The RAP framework helps identify and mobilize stakeholders who can effectively deliver climate change adaptation by comparing several proposed participatory structures with those in existence.

The RAP framework builds a robust action approach that allows one to develop plans for long-term actions and emerging needs while responding to immediate climate change impacts. The RAP framework follows five steps to aid in the planning of appropriate interventions to respond to the challenge of climate change. The project leader acts as a process facilitator, while other participants support the RAP leader in developing the proposed participatory mapping and action plans.

Step 1: Mapping the baseline stakeholder networks, those active or affected by the adaptation. Several mapping approaches can be used, such as backward mapping and forward mapping. This step produces a baseline network of actors across multiple levels while maintaining a pathway that focuses on interest.

Step 2: Selection of actors identified from the baseline network and adaptation interventions. The choice of participants may vary with the region but should be representative of multiple levels.

Step 3: Mapping of the participatory network. The actors selected in Step 2 participate in a workshop to develop network maps and links needed for implementing the selected adaptation actions.

Step 4: Overlaying the participatory network map produced in Step 3 onto the baseline network produced during Step 1. The process identifies implementation pathways based on actual relations rather than assumptions.

Step 5: Developing robust action plans. Participants produce detailed action plans using previous relational data to implement a chosen intervention. Action plans are broken down into detailed, concrete steps that define tasks and roles.

The RAP framework is useful in planning adaptation interventions in climate-vulnerable, multi-actor, and multi-level settings. This framework can visualize the adaptation space and reduce the complexity of implementing chosen adaptations.

The target user for the RAP framework includes governments, ministries, and NGOs that play active roles in climate projects. Actors at the community level and the private sector can also gain insights from this framework.

Robust Decision Making (RDM)

The Robust Decision Making (RDM) methodology is a framework for decision-making that considers uncertainty and helps to make decisions that fit a wider range of future scenarios. The best option approach is more appropriate when it is easy to predict the future state of the environment, but under deep uncertainty, it is hard to select suitable adaptation interventions. Therefore, there is a need to use a robust option approach to minimize disappointment of the intervention not working rather than optimizing outcomes.

RDM combines decision analysis, assumption-based planning, scenarios, and exploratory modeling and uses computational tools to make better predictions for better decisions under uncertainty. The methodology provides a framework that identifies weaknesses in the current strategies and determines adaptive strategies that will be successful across a broad range of future scenarios. The process is iterative, and it involves building on or refining interventions to improve the strategies.

The process followed in the RDM framework includes:

Step 1: Decision framing. Through a participatory process, stakeholders define objectives, strategies to achieve the objectives, uncertainties, and relationships (between objectives, strategies, and uncertainties). From this exercise, the analyst develops a design, defining a set of futures, against which to evaluate the initial strategies.

Step 2: Evaluate strategy across futures. The strategies identified in Step 1 are evaluated in many futures, and from the simulations, a large database of outcomes for each strategy are generated.

Step 3: Vulnerability analysis. In this step, the decision-making team identifies, explores, and characterizes vulnerabilities using scenario discovery (SD) algorithms. This aids in identifying uncertainties that make the strategies to be unworkable. After the uncertainties are identified, the decision makers collaborate with stakeholders to refine the conditions to describe the decision-relevant scenarios.

Step 4: Tradeoff analysis. Different strategies are evaluated to analyse the tradeoffs. The process is participatory, where the decision makers and stakeholders are provided with tradeoff information about the likely consequences on different strategies. The information is used to design a robust adaptive strategy.

Step 5: New futures and strategies. The decision-making team evaluates the robust strategies with tradeoffs against the existing strategies to establish the final strategies developed from RDM. The final strategies developed from RDM process are referred to as the 'adaptive decision strategies'.

Adaptation Database for Planning Tool (ADAPT)

The Adaptation Database for Planning Tool (ADAPT) is a cloud-based tool that uses a database management system technology housed within a national statistical system, and multiple users can use it simultaneously. It helps local government users to protect their communities from the impacts and costs associated with predicted climate change.

ADAPT provides adaptation planning processes and links to updated climate science tools. The tool takes users through the process of assessing vulnerabilities, setting goals for resiliency, and developing plans that integrate into the hazard and comprehensive planning efforts. Cities such as Keene in New Hampshire have applied the ADAPT tool to develop their climate adaptation action plans.

The process has five milestones:

1. Initiating an effort like coming up with a committee to identify vulnerabilities and opportunities in the community, set goals and targets to achieve climate resilience, and train them.

2. Conducting a resilient study: assessing and prioritizing predicted regional impacts goals e.g., how rising global temperatures will impact land use, agriculture, disaster management, etc.

3. Setting preparedness/action goals–including opportunities, goals, and specific targets.

4. Implementing a preparedness/action plan.

5. Monitoring, evaluating, and reassessing.

Climate Canvas

Climate Canvas is an innovative, valuable, and effective artificial intelligence (AI)-based tool aimed at assisting small and medium-sized enterprises (SMEs) in managing and adjusting to the impacts of climate change. The tool builds on the Business Model Canvas hence a similar layout and functionality. The tool is made to protect small businesses, especially in developing countries, from adverse climate change impacts by identifying the vulnerabilities of these businesses and creating an adaptation plan to be implemented during forecasted climate change.

The Climate Canvas provides a framework that can easily be integrated into any business model. The tool helps small businesses and enterprises to take on impactful climate change mitigation intervention effectively and actively. Although the framework is designed for SMEs, its flexibility offers an advantage by ensuring that it can also be applied to other businesses, despite their sizes. With the Climate Canvas, SMEs can protect their revenue stream and assets against climate change impacts, reduce their carbon emission and protect and increase their profits. The tool targets SME managers.

The main objectives of the Climate Canvas include:

1. Determine strategies to help SMEs safeguard their revenue streams and resources from the negative effects of climate change.

2. Provide adaptation strategies that help the SMEs mitigate any impacts of climate change.

3. Lower the carbon footprint of businesses, contributing towards a cleaner environment.

4. Capitalize on market opportunities by identifying avenues for creating eco-friendly products and services.

Climate Canvas offers a comprehensive one-page template with nine components that touch on climate change risks to SMEs, such as operational vulnerabilities, supply chain risks, devotion steps to lowering GHG emissions, the criterion of monitoring the progress and effectiveness of the adaptation strategies, and financial costs and benefits. It is an action-based framework that through the nine components, prompts users to identify any climate risks and set a basis for identifying effective mitigation steps.

Climate Canvas provides an agile approach that allows its users to constantly make any updates to mitigation strategies depending on any feedback obtained from business stakeholders or changing circumstances. Climate Canvas has leveraged AI tools such as Chat GPT and application programming interface (API), which help users in business analysis and strategy formulation. With little business data, the AI helps users in filling the nine blocks in the canvas hence generating relevant mitigation steps and monitoring metrics. Climate Canvas has been successfully implemented in SMEs that operate in industries that are most vulnerable to climate change, such as energy, agriculture, waste, and water management.

Adaptation Support Tool (AST)

Developed by the European Climate Adaptation Platform Climate-ADAPT, the Adaptation Support Tool (AST) is a guidance tool that offers support to policymakers at the national level to strengthen resilience in target areas and draw adaptive measures to mitigate impacts of climate change. The AST encompasses all the primary steps of creating, executing, overseeing, and assessing strategies and plans for adapting to climate change. Although it was developed to help coordinators at the national level, the tool can also aid subcounty planners to design and evaluate their adaptation strategies.

The AST works on mitigating climate change risks by controlling the pollution of water bodies by monitoring the quality of water in the selected area, controlling drought by monitoring the ability of groundwater recharge and storage in the area, flood prevention by monitoring water runoff depending on the landscape and water retention compared to the expected rainfall, and heat stress reduction by assessing the cooling capacity of the area via evaporation and also the shade coverage of the target location. In addition, the tool also considers the efficacy and the costs of the selected adaptation intervention. Target users include environmental managers, policymakers, urban planners, and designers.

The main objectives of the Adaptation Support Tool (AST) are:

1. To aid national coordinators in creating and monitoring adaptation strategies in the face of climate change

2. To assess the effectiveness and cost of the interventions selected for the target area.

The AST comprises six sequential steps that collectively facilitate the adaptation:

Step 1: Building the basis for adaptation. This involves creating a process, identifying the resources needed, and seeking support from the government.

Step 2: Evaluating the vulnerabilities and risks posed by climate change.

Step 3: Identifying the plan of action or the available adaptation option, depending on the risks identified.

Step 4: Evaluating the adaptation options available, which involves comparing the options and prioritizing some over others.

Step 5: Putting into effect the identified adaptation options.

Step 6: Assessing and monitoring the strategies implemented, to check their effectiveness and the costs incurred.

Through the outlined steps, users can examine the vulnerabilities and risks associated with climate change, evaluate the available adaptation options, and assess the expected outcomes of these efforts. Users can also draw on the provided adaptation strategies that apply to the target area to strengthen their adaptive capacity and lower their vulnerability to climate change.

Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG)

The Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG) was developed by the Swiss Agency for Development and Cooperation (SDC). It systematically integrates climate, environment and disaster risk reduction (DRR) into development cooperation and humanitarian aid to enhance the overall resilience of systems and communities (SDC 2019). CEDRIG helps to assess whether existing and planned strategies, programs and projects are at risk from climate change, environmental degradation and natural hazards (SDC 2019). It also assesses whether these interventions could further exacerbate GHG emissions, environmental degradation or risks of natural hazards (SDC 2019). It has three independent modules including:

1. *CEDRIG light (rapid risk and impact screening):* This module, which can be completed within a maximum of one hour, is as an initial screening tool. It helps evaluate whether strategies, programs, or projects face significant risks due to climate change, disasters, and/or environmental degradation (from a risk perspective). Additionally, it assesses whether they have the potential to significantly impact GHG emissions, the environment, and potentially create new risks or worsen existing risks (from an impact perspective). Based on the results obtained from this module, a decision is made whether a more detailed assessment is required. This assessment can be either the CEDRIG strategic or CEDRIG operational assessment, depending on the specific needs and context.

2. *CEDRIG strategic (detailed assessment and integration):* This participatory module helps integrate climate change, environment, and disaster risk reduction into existing or planned strategies or programs. It takes approximately one day (excluding preparation time) and focuses on two perspectives: managing risks and preventing negative impacts. By considering adaptation, degraded environments, disaster risk reduction, and avoiding climate-related and environmental harm, the module ensures a comprehensive approach. It involves stakeholders and promotes sustainability and resilience.

3. *CEDRIG operational (detailed assessment and integration):* This module is a simple way to incorporate climate change, environment, and disaster risk reduction into a project. It takes about two to three days to complete, not including preparation time. The module focuses on two main perspectives. The first perspective is about managing risks, which includes adapting to climate change, addressing degraded environments, and integrating measures to reduce disaster risks. The second perspective is about minimizing impacts. This means

avoiding negative effects on the climate and the environment and preventing the creation of new risks or worsening existing risks associated with natural hazards.

CEDRIG is accessible at: https://www.cedrig.org/.

Training manual on bundled climate-smart agriculture, climate information services and One Health technologies for priority value chains

The manual serves as a supplementary resource to the prioritized and bundled climate-smart Agriculture (CSA) and climate information services innovations, with a focus on One Health sensitivity. It is specifically designed as an extension and training tool for trainers of trainees (TOT) and extension agents who work with smallholder farmers, particularly in the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) project intervention communities. The manual offers valuable guidance, and it is expected to be highly beneficial to various users including agriculture extension agents (AEAs), farmers, students, and other end users. The modules provided in the manual aim to enhance crop production in specific target agro-ecologies. The content of the manual includes climate information services, climate-smart agriculture innovations, and interventions related to One Health. These interventions have been prioritized for maize, cowpea, yam, sweetpotato, and tomato value chains. By utilizing the modules outlined in the manual, it is anticipated that users will be able to apply the knowledge and strategies effectively, leading to increased crop production in the specified agro-ecologies.

Training materials needed are:

- Flip charts stand and sheets.
- Markers (black, green, and blue).
- Colored stickers.
- Notebooks, pens, and pencils.
- Printed posters for presentations where there is no projector.

Translating climate-smart agriculture policies into action: A guidebook for operationalizing climate-smart agriculture into local action planning

Numerous countries have made significant strides in translating their climate goals into action by implementing laws and policies focused on adaptation and mitigation. However, a critical challenge remains in translating these national policies into localized actions. To address this gap, it is necessary to enhance the capacity of technical officers and policymakers at various levels, including subnational governance and local communities, to effectively implement climate policies. In light of this, the guide has been developed to facilitate sensitization and capacity building workshops for subnational agricultural officers. The guidebook offers a comprehensive framework that outlines a series of lessons and activities to be conducted throughout the workshop. Additionally, it provides a detailed day-by-day agenda to structure the workshop proceedings. The objective of the workshops is to equip subnational agricultural officers with the necessary knowledge and skills to effectively implement climate policies at the local level. By following the guidebook, workshop participants will gain valuable insights and practical tools to bridge the gap between national policies and local actions in the agricultural sector. This guidebook can support the development of new policy guidelines, commitments, and strategies globally or nationally, or the review or reform of existing ones. It can help translate international and national objectives and commitments into local action.

Climate-smart agriculture training manual for training of trainers

In the drylands of many African countries, where poverty is widespread, it is crucial to enhance and improve the agricultural systems to ensure food security and resilience to climate change. The promotion of climate-smart agriculture has been widely advocated to achieve sustainable farming practices and strengthen the resilience of livelihoods and ecosystems. This training manual aims to enhance the capabilities of agricultural extension officers, lead farmers, SMEs, and Farmer Producer Organizations (FPOs) in scaling Climate Information Services (CIS) and CSA innovations. The goal is to attain food and water security and enhance climate resilience. The training manual covers a range of topics, including a comprehensive understanding of CSA, suitable technologies, and practices for various agro-ecological zones in Kenya, and the integration of Gender Equality and Social Inclusion (GESI) in CSA.

Purpose of training manual

The purpose of this training manual is to provide knowledge and skills to government extension officers and lead farmers on the concept of CSA, empower them to train farmers on appropriate technologies, innovations, and management practices against climate change risks.

Specifically, this training manual helps the participants to:

- Understand the concept of climate-smart agriculture (CSA) and component technologies and practices.
- Become familiar with principles of adapting CSA technologies, practices, and solutions in diverse geographic locations.
- Appreciate the importance of GESI in designing, implementing, and monitoring CSA interventions.

Training summary

Sessions	Training methods	Training materials	Time duration
Introductions to the module (ask participants about their expectations for the training) 1. Understanding the meaning of CSA and practices in agricultural production–gender-based constraints in adoption of CSA.	Sharing Presentations Use of infographics/ pictures/ videos	Program Objectives Marker/ felt pens Sticky leaf pads PowerPoint presentation.	1 hour 30mins
2. Choice of gender Smart CSA practices	Plenary discussions Presentations	PowerPoint presentation Flip chart	1 hour 30 mins
3.Contribution of climate information services to local CSA practices	Plenary discussions Presentations	Power point presentation Flip charts Marker /felt pens	45 mins

Land Degradation Surveillance Framework (LDSF)

The LDSF training not only helps field staff to conduct surveys, but also provides an opportunity for research staff to acquire knowledge and tools on landscape assessment, which will be useful in assessing land degradation and soil health metrics in current and future projects. The goals of the training guide are to:

- Provide in-the-field training for participants on the Land Degradation Surveillance Framework (LDSF) methodology.
- Equip the team with the necessary materials and equipment to carry out the LDSF field survey immediately following the training.
- Expose participants to a non-biased ecosystem health sampling framework with multiple geo-referenced indicators.
- Provide an insight into sample processing.

For the LDSF field methods, participants are trained on the various modules that make up the framework, including soil erosion observations, soil sampling, land use characterization, shrub and tree density and biodiversity measurements, landform and landcover classification, soil infiltration, uploading of the ODK forms, and soil sample processing, labelling, and packaging.

Framework for the assessment of skills for national adaptation planning

As awareness of the climatic risks has increased, it has become evident that a broader range of skills and capacities are required. The framework for the assessment of skills for national adaptation planning offers a way of assessing the skills gap that a country may have in designing and implementing a national adaptation plan. Skills assessment can help a country to better understand the training needs of those most involved in adaptation planning. This is achieved by:

1. identifying and describing existing skills-sets in place (management, technical, and participatory);

2. locating these skills sets at different implementation levels (policy, organizational, and operational), and

3. identifying the gaps where additional skills development is required.

The skills assessment framework is made up of several elements: an assessment tool providing a benchmark set of institutional capacities and skills against which a country can assess its needs; and a step-by-step guide on how to implement a national skills assessment.[3]

3 A step-by-step guide can be accessed here: https://www4.unfccc.int/sites/NAPC/Documents/Supplements/UNITAR%20sanap%202015.pdf.

4.2 A summary of the adaptation planning tools and frameworks

This section presents a summary matrix of the identified tools and frameworks. It provides a brief description of the tools and frameworks and the sources. It further provides links to the identified tools and frameworks.

Table 1. Summary of adaptation planning tools and frameworks

Name of tool/framework	Authors/affiliation	Summary description of the tool
1 Tracking Adaptation in Livestock Systems (TAiLS) tool	International Livestock Research Institute (ILRI) http://3.108.47.178/	The TAiLS tool, which was developed in close collaboration with governments, livestock keepers, and researchers, is designed to enable government officials to track and report on progress in adapting to the impacts of climate change in the livestock sector. The tool captures various elements of the adaptation cycle including hazards, impacts, adaptation strategies, adaptive capacities, and goals. It also captures system dynamics (biophysical, social, and economic dimensions of a system) as well as diverse adaptation results (based on an integration of input, output, process, and outcome indicators). To track progress along these components, the tool uses relevant indicators of adaptation progress at household, subnational, and national scales. The use of a composite index and visual representations of results in the tool supports the integration of these diverse components while illustrating adaptation progress across space and time in a simple and accessible way.
2 Community based Risk Screening Tool–Adaptation and Livelihoods (CRiSTAL)	International Institute for Sustainable Development (IISD), International Union for Conservation of Nature (IUCN), SEI-US https://www.iisd.org/cristaltool/ https://www.iisd.org/system/files/publications/cristal_user_manual_v5_2012.pdf	CRiSTAL is a project planning tool that helps users design activities that support climate adaptation at the community level. CRiSTAL enables local decision makers to assess the impact a project may have on the resources of a community and modify projects to reduce vulnerability and enhance adaptive capacity by incorporating adaptation methods. This decision support tool is a user-friendly process for planners and managers to identify the links between the livelihoods of locals and climate. CRiSTAL guides users through a few analytical steps: 1) describing livelihoods context; 2) analysing climate risks; 3) revising existing project activities; 4) designing new project activities; 5) identifying key elements for the monitoring and evaluation framework.
3 ClimateWizard	The Nature Conservancy, International Center for Tropical Agriculture (CIAT), University of Mississippi https://www.fs.usda.gov/ccrc/tool/climate-wizard	The ClimateWizard tool can be used to view historic temperature and rainfall maps, view state-of-the-art future predictions of temperature and rainfall, and view and download climate change maps in a few easy steps. ClimateWizard enables technical and non-technical audiences alike to access leading climate change information and visualize the impacts.

4 Land Use Portfolio Modeler (LUPM)	US Geological Survey https://pubs.usgs.gov/tm/tm11c4/	LUPM is a tool for modeling, mapping, and communicating risk. It is designed to help public agencies and communities understand and reduce their vulnerability to, and risk of natural hazards. Data inputs include the probability of the hazard event, the planning time horizon, the assets at risk (e.g., livestock), the spatial probabilities of damage, the dollar value and/or vulnerability of each asset, and the cost and effectiveness of the risk-reduction measures being considered. LUPM calculates estimates for the total cost, number of locations mitigated, return on investment, expected loss, and community wealth retained. Finally, the user can display maps showing the results of each adaptation policy and compare and rank the policies according to their own priorities.
5 weADAPT	EcoAdapt/Island Press http://www.weadapt.org	weADAPT.org is an online 'open space' on climate adaptation issues which allows practitioners, researchers, and policymakers to access credible, high-quality information and to share experiences and lessons learned with the weADAPT community. It is designed to facilitate learning, exchange, collaboration, and knowledge integration to build a professional community of practice on adaptation issues while developing policy-relevant tools and guidance for adaptation planning and decision-making.
6 Climate Change Vulnerability Index	NatureServe https://www.natureserve.org/ccvi_3-download	The Climate Change Vulnerability Index uses a scoring system that integrates predicted exposure to climate change within an assessment area and three sets of factors associated with climate change sensitivity: 1) indirect exposure to climate change, 2) species-specific factors (including dispersal ability, temperature and precipitation sensitivity, physical habitat specificity, interspecific interactions, and genetic factors), and 3) documented response to climate change. The index can help users to identify adaptation options.
7 Participatory Social Return on Investment (PSROI)	Robert Enterprise Development Fund in the U.S; SROI Network (applied by Chaudhury et al. 2016) https://cgspace.cgiar.org/handle/10568/36117	PSROI is a structured framework for multi-stakeholder planning and costing locally appropriate methods and interventions for adapting to climate change. SROI is a five-step analysis process that includes 1) identifying and selecting relevant stakeholders for participation in planning and costing process; 2) applying multi-stakeholder participatory process to select adaptation theme for costing; 3) designing appropriate adaptation intervention using technical experts to address identified challenges; 4) measuring the economic, social and environmental outcomes of designed intervention; 5) validating and comparing baseline cost-benefit with field data and stakeholder input. In the case of climate change adaptation, this process begins with choosing the adaptation theme, co-designing appropriate adaptation strategies and pathways that build on existing strengths, and valuation of the economic, social, and environmental costs and benefits over the lifetime of these actions.

8 Comprehensive Livestock Environmental Assessment for Improved Nutrition, a Secured Environment, and Sustainable Development along Livestock and Fish Value Chains (CLEANED)	Alliance of Bioversity International, the International Center for Tropical Agriculture (ABC CIAT), and ILRI https://cgspace.cgiar.org/handle/10568/111558	CLEANED is a desktop application tool that quantifies the environmental footprints of livestock systems and value chains. The tool is designed to provide rapid results in a data scarce environment. With a few clicks of a button, it calculates the land and water requirements, soil health impacts, carbon sequestration and GHG emissions associated with different types of livestock enterprises and estimates positive or negative changes because of different intervention scenarios. The tool is most useful in the design and planning phase of projects, initiatives or programs that investigate farm-level interventions because it allows users to understand impacts and trade-offs, and to better design sustainable livestock systems.
9 Robust Adaptation Planning (RAP) framework	Chaudhury et al. (2017)	The scope of RAP is to assist in the planning of appropriate interventions to respond to the challenge of climate change adaptation. RAP leverages existing institutional structures and stakeholder networks by using diverse actors to plan, sequence and time adequate strategies across many levels to reduce risks of failure and avoid duplication. At the heart of RAP lies a participatory approach that promotes a collective response from actors. Actors identify adaptation interventions and important relations to develop wide networks, highlighting potential pathways for connecting central policy to local implementation and vice versa.
10 Robust Decision Making (RDM) methodology	The RAND Corporation https://www.rand.org/pubs/external_publications/EP67834.html#:~:text=RDM%20combines%20Decision%20Analysis%2C%20Assumption-Based%20Planning%2C%20scenarios%2C%20and,to%20identify%20policy-relevant%20scenarios%20and%20robust%20adaptive%20strategies.	Robust solutions can usually be achieved by selecting options that minimize the potential for regret (the difference between what a given decision would achieve and what the best decision could have achieved). The RDM methodology suggests starting from existing plans and working with decision makers and stakeholders to define what would be considered a failure or unacceptable outcome. The vulnerabilities identified through this process can help identify options and opportunities to reduce or manage them, and to make the considered system less vulnerable.
11 KAZNET	ILRI https://www.drylandinnovations.com/kaznet	KAZNET is a tool developed to monitor the performance of rangelands, markets, and households using high-frequency data to understand the mechanisms through which drought impacts households. The tool uses crowdsourcing techniques to collect high-frequency data on key indicators of drought shocks.
12 Invasive Species Forecasting System (ISFS)	NASA and the Maryland Department of Natural Resources https://ntrs.nasa.gov/citations/20120009081	Combines USGS science and NASA Earth observations with software engineering to provide regional-scale patterns of invasive species and vulnerable habitats.
13 Adaptation Database for Planning Tool (ADAPT)	International Council for Local Environmental Initiatives (ICLEI) – Local Governments for Sustainability https://www.cakex.org/tools/adaptation-database-and-planning-tool-adapt	An online database that guides users through ICLEI's 5 Milestones for Climate Adaptation planning framework. ADAPT walks you through the process of assessing your vulnerabilities, setting resiliency goals, and developing plans that integrate into existing hazard and comprehensive planning efforts.

14 Ecosystem-Based Management Tools Network	NatureServe and Open Communications for the Oceans (OCTO) https://toolkit.climate.gov/tool/ecosystem-based-management-ebm-tools-network)	A network of tool providers and practitioners that works to bring geospatial and other tools to planning processes. At the EBM Tools Network website, you can find: an online database of tools, training resources, webinars, and links to case studies.
15 Climate Sensitivity Database	University of Washington	Intended for use by natural resource managers, the Climate Sensitivity Database by the University of Washington and key collaborators helps to evaluate the sensitivity of the species and ecological systems of the Pacific Northwest to climate change. This digital database summarizes the inherent climate change sensitivities for species and habitats of concern throughout the Pacific Northwest and will provide resource managers and decision makers with some of the most basic and most important information about how species and systems will likely respond to climate change.
16 Hazards US Multi-Hazard (HAZUS-MH)	United States Federal Emergency Management Agency (US FEMA) https://coast.noaa.gov/digitalcoast/tools/hazus-mh.html	FEMA's HAZUS-MH is a powerful risk assessment methodology for analysing potential losses from floods, hurricane winds and earthquakes. Scientific and engineering knowledge is coupled with the latest geographic information systems (GIS) technology to produce estimates of hazard-related damage before, or after, a disaster occurs. Potential loss estimates are analysed including physical damage, economic loss, and social impacts.
17 Sea Level Rise Affecting Marshes Model (SLAMM)	Warren Pinnacle Consulting, Inc https://coast.noaa.gov/digitalcoast/tools/slamm.html	SLAMM accounts for dominant processes in wetland conversion and shoreline modifications during long-term sea level rise (SLR). It provides more detail than static coastal topography alone, e.g., assessing the contribution of sea water inundation to the conversion of one habitat type to another based on elevation, habitat type, the presence of structures such as dikes, and other variables. SLAMM also accounts for relative SLR calculated as the sum of historic global sea level trends, site-specific coastal elevation changes due to subsidence and other factors and accelerated global SLR due to global warming.
18 CommunityViz	Placeways, LLC https://communityviz.com/	CommunityViz is an ArcGIS extension that adds interactive analysis tools and a decision-making framework to the ArcGIS platform. Scenario 360 helps you view, analyse and understand land-use alternatives and impacts. A GIS-based decision support tool, it shows the implications of different plans and choices. It supports scenario planning, sketch planning, 3D visualization, suitability analysis, impact assessment, growth modeling and other popular techniques. Its many layers of functionality make it useful for a wide range of skill levels and applications.

19 NatureServe Vista	NatureServe https://www.natureserve.org/products/natureserve-vista	NatureServe Vista 2.5 is a decision support system for conservation planning and integrating conservation with other assessment and planning activities such as land use, transportation, energy, natural resource, and ecosystem-based management. NatureServe Vista enables users to evaluate, create, implement, and monitor land use and resource management scenarios that operate within the existing economic, social, and political context to achieve conservation goals. The tool operates on an ArcGIS platform. The latest version (v2.5) integrates interoperability with the NOAA Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) and other hydrologic models to support integrated land-water assessment and planning.
20 Maxent	Center for Biodiversity and Conservation (CBC) and American Museum of Natural History (AMNH)t https://biodiversityinformatics.amnh.org/open_source/maxent/	The Maxent program produces models of species geographic distributions based on presence-only data. It was designed specifically for modeling distributions when users have access to historical and/or current species localities but do not have data on sites where the species is known to be absent. Latitude/longitude information on where species have been found and environmental data potentially correlating with species' distributions are the required input. When climate-related factors are believed to drive the current distribution of a species, these variables can be used to generate a model of the current climate envelope, and then the software can project that preference onto models of future climates.
21 NEAFWA Regional Vulnerability Modeling	Northeast Association of Fish & Wildlife Agencies (NEAFWA)	This modeling process provides estimates of how the vulnerabilities of important fish and wildlife habitats vary geographically across the US northeastern states–an important regional context within which to make conservation planning decisions. The vulnerability model has now been developed and is currently being applied to a sample of 22 habitat types.
22 Land Change Modeler (LCM)	Conservation International https://gis.harvard.edu/land-change-modeler-20-arcgis	Land Change Modeler (LCM) is a planning and decision support tool for rapid assessment and mapping of land change. Users of LCM can quickly assess land cover change, simulate future land change scenarios, and estimate species impacts. LCM can be used to prioritize conservation and planning initiatives. It reduces the complexity of change analysis, resource management, and habitat evaluation to support decision-making and innovative land planning. LCM provides users with access to maps and assessments in one click hence it is very rapid. It incorporates special tools that assess Reducing Emissions from Deforestation and forest Degradation (REDD) mitigation strategies of climate change in addition to usual projection conditions. REDD in LCM accounts for all CO_2 and non-CO_2 baseline emissions.

23 Social Vulnerability Index (SoVI)	University of South Carolina https://sc.edu/study/colleges_schools/artsandsciences/centers_and_institutes/hvri/data_and_resources/sovi/index.php	SoVI is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. It graphically illustrates the geographic variation in social vulnerability. It shows where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce the pre-existing vulnerability. The index synthesizes 32 socio-economic variables, which the research literature suggests contribute to reduction in a community's ability to prepare for, respond to, and recover from hazards. The data were culled from national data sources, primarily those from the United States Census Bureau.
24 Climate Adaptation Knowledge Exchange (CAKE)	EcoAdapt http://www.cakex.org	Includes georeferenced case studies, directory, tools, and resource library. You can search by text, map, or both.
25 System for Assessing Vulnerability of Species (SAVS) to Climate Change	United States Department of Agriculture, Forest Service Rocky Mountain Research Station https://www.fs.usda.gov/ccrc/index.php/tool/savs-system-assessing-vulnerability-species-climate-change	The System for Assessing Vulnerability of Species (SAVS) quantifies the relative impact of expected climate change effects for terrestrial vertebrate species. The SAVS uses 22 criteria related to expected response or vulnerability of species in a questionnaire to provide a framework for assessing vulnerability to climate change. The online questionnaire is completed using information gathered from published materials, personal knowledge, or expert consultation.
26 Framework for categorizing the relative vulnerability of threatened & endangered species to climate change	National Center for Environmental Assessment (NCEA) https://citeseerx.ist.psu.edu/doc/10.1.1.513.3979	This tool is a method without associated software. The method involves an evaluative framework composed of four modules. Module 1 categorizes baseline vulnerability to extinction or major population reduction. Module 2 scores the likely vulnerability of a species to future climate change, including the species' potential physiological, behavioural, demographic, and ecological response to climate change. Module 3 combines the results of Modules 1 and 2 into a matrix to produce an overall score of the species' vulnerability to climate change. Module 4 is a qualitative determination of uncertainty of overall vulnerability based on evaluations of uncertainty done in each of the first 3 modules.
27 Coastal Inundation Toolkit	Digital Coast Partnership Group, National Oceanic and Atmospheric Administration (NOAA) https://toolkit.climate.gov/tool/coastal-inundation-dashboard	The toolkit assists individuals in assessing their vulnerability to coastal inundation, hence preparing for flooding by formulating mitigation adaptation and recovery plans. Its purpose is to guide communities in understanding their susceptibility to flooding and identifying appropriate measures to mitigate the associated risks.
28 Climate Vulnerability and Capacity Analysis framework	CARE https://careclimatechange.org/cvca/	Climate Vulnerability and Capacity Analysis (CVCA) is a framework aimed at collecting and evaluating data pertaining to various communities in order to determine their ability to adjust to the effects of climate change, as well as to identify measures that can be taken to enhance their resilience. CVCA prioritizes the understanding of climate change risks, impacts, and adaptation at the community level. It is a participatory framework that promotes discussions between the local communities, governments, and other stakeholders.

29 The Climate Change Resilience and Adaptation Planning Tool (CC-RAPT)	Marine Subgroup of IUCN, World Commission on Protected Areas (WCPA) and Climate Change Specialist Group https://marineprotectedareas.noaa.gov/sciencestewardship/climatechangeimpacts/climate-change-resilience-adaptation-planning-tool.html	The Climate Change-Resilience and Adaptation Planning Tool (CC-RAPT) is an online interface and a scoring tool for assessing the impact of climate change and what makes the marine environment vulnerable and the preparedness of the marine ecosystem in the face of the climate crisis.
30 Northeast Climate Data	National Center for Environmental Information (NCEI)	The Northeast Regional Climate data contains data sets that include a complete collection of historical climate data for the northeastern United States and continually updated National Weather Service observations and forecasts. The Northeastern climatic data provide scientific information, tools, and techniques that managers and other parties interested in land, water, wildlife, and cultural resources can use to anticipate, monitor, and adapt to climate change in the Northeast region. Additionally, models are used in the data sets that estimate variables such as solar radiation and evapotranspiration which are rarely observed.
31 NOAA Coastal Service Center (CSC) Roadmap	National Oceanic and Atmospheric Administration's Coastal Service Center https://coast.noaa.gov/	The National Oceanic and Atmospheric Administration's Coastal Service Center (NOAA's CSC) roadmap is a framework for state coastal managers and other participants to follow as they develop and implement climate change adaptation plans for coasts, which are particularly susceptible to climate change. It is designed to allow participants to foster dialogues on risks and vulnerability along coastal town centres and regional planning organizations.
32 Digital Coast	Russell Jackson, NOAA Office for Coastal Management https://coast.noaa.gov/digitalcoast/	The website has proved beneficial in aiding its users in policy formulation, planning adaptation strategies, and steps to mitigate the negative consequences of climate change. Digital Coast serves as a hub for information aimed at tackling pressing coastal issues such as climate change, preservation of the coastal ecosystem, land utilization, and hazard prevention. The website provides up-to-date data that is publicly available and searchable online.
33 Climate Canvas	Arun Hsu and Vladan Raznatovic https://www.climatecanvas.io/home/home.php	The tool draws its inspiration from the Business Model Canvas and has a similar layout and functionality. It works to come up with ways to protect small businesses, especially in developing countries from adverse climate change impacts by identifying the vulnerabilities of these businesses and creating an adaptation plan to be implemented during forecasted climate change.
34 Google Mashup	GameStop Corp (GME)	Mashups can provide decision support tools in the study of the impacts of climate change and variability on health and enhance the development of more effective adaptation strategies. Mashups that use Googe Earth and Maps may offer improved data linkages between climate, weather, and environmental data with other health and well-being databases and expand access to these linked data.

35	Spatial Trends in Coastal Socioeconomics (STICS)	US Census Bureau and the Bureau of Economic Analysis	STICS is a map-based website that provides georeferenced demographic data from the US Census Bureau and the Bureau of Economic Analysis that is time-based. It compiles data to estimate attributes in several coastal management jurisdictions. Analyses of these data can reveal socio-economic trends of the coastal regions in the country such as watersheds, estuaries, floodplains, counties, states etc.
36	Adaptation Support Tool (AST)	European Climate Adaptation Platform https://climate-adapt.eea.europa.eu/en/knowledge/tools/adaptation-support-tool	The adaptation support tool is a guidance tool that offers support to policymakers at the national level in strengthening resilience in target areas and drawing adaptive measures to mitigate the negative effects caused by climate change. The adaptation support tool encompasses all the primary steps pertaining to creating, executing, overseeing, and assessing strategies and plans for adapting to climate change.
37	Self-evaluation and holistic assessment of climate resilience of farmers and pastoralists (SHARP)	FAO https://www.fao.org/in-action/sharp/sharp-tool/en/	The framework used by SHARP enables relevant comparison analysis to strengthen the sustainable productive capacity of the small-scale household with respect to climate change. SHARP basically assesses smallholder farmers and pastoralists' resilience to climate change by identifying the main weaknesses and strengths of farming systems and agriculture-based households, building on their flexibility, learning and knowledge of farmers and pastoralists through a participatory manner. SHARP is also useful for monitoring and evaluating climate change adaptation in agriculture sectors, and to further research in academia.
38	Resilience index measurement and analysis (RIMA)	FAO https://www.fao.org/agrifood-economics/areas-of-work/rima/en/	The RIMA tool aids in the analysis of how different households manage and adapt to unexpected events and pressures. It also compares different households, for example, where different genders head the households and how their responses stressors vary in a given location.
39	Stocktaking for national adaptation planning (SNAP)	German Agency for International Cooperation (GIZ) https://www.napcentral.org/supplementary-materials/53#:~:text=GIZ%20has%20developed%20the%20Stocktaking%20for%20National%20Adaptation,for%20initiating%20the%20National%20Ad-aptation%20Plan%20%28NAP%29%20process.	The tool targets technical support units from ministries, donor agencies, organizations supporting NAP planning, and other stakeholders. The main component of the tool is an assessment of the country's needs and capacities while allowing for a critical perspective on the overall NAP process. It provides a stocktake of a country's planning capacities, both existing and intended, and aids in determining the country's starting point for launching the National Adaptation Plan (NAP) process; as the country heads towards the achievement of the Nationally Determined Contributions (NDC) goals that contribute to Paris Agreement's goals accomplishment.

40 Adaptation monitoring and assessment tool (AMAT)	TANGO Resilience Assessment Framework' and International Institute for Environment and Development https://www.thegef.org/documents/gef-climate-change-adaptation-tracking-tool	AMAT was introduced to track the progress of all Least Developed Countries Fund (LDCF) projects in tracking the achievement of the specific project outcome and output indicators established at the portfolio level under the LDCF/SCCF results framework for GEF-5. It includes specific examples of outcomes and output indicators for different sectors and adaptation objectives. The tool also has a comprehensive drop-down menu suggesting indicators to project proponents and allows an option for 'other.'
41 Intelligent Agricultural Systems Advisory Tool (iSAT)	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) https://www.sciencedirect.com/science/article/pii/S2405880723000651	iSAT is an advisory tool that provides brief and precise advice to farmers on their phones. It is flexible and can accommodate any number of farmers. One strategy for assisting smallholder farmers to cope with climate change and variability and change is the provision of climate services to improve decision-making around agricultural system planning and management both pre-season and in-season.
42 Climate Change Response Framework (CCRF)	The Northern Institute of Applied Climate Science (NIACS) https://forestadaptation.org/	The purpose of the CCRF framework is to help land managers understand potential impacts and integrate climate change into their planning and management, closing the gap between scientific research on the impacts of climate change and natural resource management on the ground: the major challenge they face currently is predicting the effects of climate change on forest ecosystems and then coming up and applying management solutions for adapting forests to future conditions.
43 Africa RiskView	World Food Programme https://www.africariskview.org/SignIn.aspx?ReturnUrl=%2f	Africa RiskView is available as an online tool and a more flexible desktop application. It was developed to translate globally available rainfall data, crop parameters and livelihood information into food security outlooks. It also calculates response costs to aid financial planning and facilitate better resource allocations before on-the ground needs assessments are produced. Governments also use Africa RiskView to understand the cost of different risk transfer options. It also serves as a component of a technical support package being provided for a potential pan-African Disaster Risk Pool, allowing participating countries to immediately access funds in the event of an extreme drought, flood, or storm
44 The Assessment of Impacts and Risks of Climate Change on Agriculture (AIRCCA) Model	Francisco Estrada, W. J. Wouter Botzen and Oscar Calderon-Bustamante (2020) https://doi.org/10.1080/17421772.2020.1754448	A user-friendly tool for rapidly assessing the impacts and risks of climate change on agriculture. It enables stakeholders to quickly evaluate the effects of climate change on maize, wheat, and rice yields at a global scale.
45 Climate Risk Screening and Management tools	United States Agency for International Development (USAID) https://www.climatelinks.org/resources/climate-risk-screening-and-management-tools	These tools are meant to improve the effectiveness and sustainability of development interventions by helping the user to assess and address climate risk. In addition, each tool helps you produce the documentation required by the Mandatory References Climate Change in USAID strategies and climate risk management for USAID projects and activities.

46	Participatory Assessment of Climate and Disaster Risk (PACDR)	Zoï, Brot für die Welt, HEKS/EPER and Bread for All https://pacdr.net/	The Participatory Assessment of Climate and Disaster Risk (PACDR) tool comprises seven modules which when combined allow users to incorporate climate and disaster risk into the planning of development projects at a community level. The tool combines information from the local community as well as scientific knowledge related to climate change in order to identify context and specific risks. It guides the user through the community assessment of both climate and disaster risks and opportunities. The assessment can then inform ongoing or planned projects and programs and community planning.
47	Climate Adaptation in Rural Development (CARD) Assessment Tool	International Fund for Agricultural Development (IFAD) https://www.ifad.org/en/web/knowledge/-/publication/climate-adaptation-in-rural-development-card-assessment-tool?p_l_back_url=%2Fen%2Fweb%2Fknowledge%2Ftools%3Fmode%3Dsearch%26catToA%3D39130752	The Climate Adaptation in Rural Development (CARD) Assessment Tool provides a platform for examining how climate change is affecting and is likely to affect the yields of 17 key crops across the 11 IFAD regions through to 2050. The tool is designed to provide quantitative data concerning climate risks faced by agricultural and rural development investments and strategies including economic and financial analyses.
48	Aqueduct	World Resources Institute (WRI) https://www.wri.org/aqueduct	Aqueduct is a tool for mapping current and future water-related risks such as floods, droughts, and stress. It enables decision makers to compare national and subnational water risks, and to identify current and future water risks to agriculture and food security.
49	Modelling System for Agricultural Impacts of Climate Change (MOSAICC)	FAO https://www.fao.org/in-action/mosaicc/models/en/	This tool provides an interdisciplinary approach to assessing climate change impacts at the national level. Its aim is to expand the knowledge of experts in climate change impacts and assist policymakers in developing informed adaptation strategies, development projects, and investments.
50	ThinkHazard!	Global Facility for Disaster Reduction and Recovery (GFDRR), the World Bank https://thinkhazard.org/en/	ThinkHazard! is a tool which enables non-specialists to identify the impacts of climatic disasters on new development projects. It considers the likelihood and severity (low, medium, or high) of occurrence of hazards in a specific country, province, or district. ThinkHazard! also provides resources on how best to mitigate the identified risks and gives a projected view on how the risks may change in the future.
51	Agricultural Model Intercomparison and Improvement Project (AgMIP)	Coordinated by the Earth Institute Center for Climate Systems Research, Columbia University https://agmip.org/	The Agricultural Model Intercomparison and Improvement Project (AgMIP) harmonizes analyses of agricultural systems at the local to global scales and looks at current and future impacts. It provides new methods for integrating stakeholder-informed scenarios into global and regional assessments of current and future agriculture and food systems.

52 Climate Risk Management in Agricultural Extension (CRMAE) Reference Guide	International Research Institute for Climate and Society (IRI), Columbia Climate School. https://cgspace.cgiar.org/handle/10568/127001	This guide provides reference materials for the Climate Risk Management in Agricultural Extension (CRMAE) course in Ethiopia. It targets extension staff and development practitioners but is also appropriate for use by NGOs or CBOs which work with farmers. It provides practical tools to assess climate risks, to use weather and climate information for informed agricultural decision-making, to effectively communicate climate information with farmers, and to integrate climate services into agricultural extension.
53 Caribbean Climate Online Risk and Adaptation tool (CCORAL)	Caribbean Community Climate Change Centre (CCCCC) https://www.caribbeanclimate.bz/	The Caribbean Climate Online Risk and Adaptation tool (CCORAL) is an online risk management toolbox with tools covering vulnerability assessment, risk assessment, adaptation option identification/appraisal, monitoring and evaluation, and awareness raising. The risk screening tool allows the user to rapidly assess a project, plan, or policy for climate-influence.
54 Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG)	Swiss Agency for Development and Cooperation (SDC) www.cedrig.org	The Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG) is an open-access online tool integrating climate, environment, and disaster risk reduction (DRR) to assess climate risks and/or impacts of projects, plans, or programs. CEDRIG uses an integrated approach to assess the risks for, and the unintended potential negative impacts of, a new strategy, program or project. It provides three different types of assessment - 'light' for rapid risk and impact screening, and 'strategic' and 'operational' assessments for a detailed approach and integration into existing or planned strategies or programs.
55 Conservation Standards	Conservation Measures Partnership (CMP) https://conservationstandards.org/about/	Open Standards for the Practice of Conservation provides a set of best practices for the implementation of conservation projects. The latest version, version 4.0, released in 2020, addresses climate change considerations in more detail than previous versions, with new tools developed for adaptation.
56 Technical guidance on comprehensive risk assessment and planning in the context of climate change	United Nations Office for Disaster Risk Reduction (UNDRR) and GIZ https://www.undrr.org/media/79566/download?startDownload=true	This document assists DRR and climate change adaptation decision makers, practitioners, and stakeholders in developing more responsive plans and policies. It provides a framework on how to apply comprehensive risk assessment and planning and it acknowledges that risks in the context of climate change are complex and systemic due to non-linear interactions amongst system components and the need for improved risk governance. The guidance can be contextualized to national and local needs.

57 Economics of climate adaptation (ECA) - Guidebook for Practitioners	Climate Adapt file:///Users/trumu/Downloads/UNU_2016_No6_Guidebook_Economics-of-Climate-Adaptation_EN.pdf	This document presents a climate risk assessment approach to inform climate adaptation investments. The approach combines risk assessment, adaptation measures and risk transfer and its results allow for the identification of cost-effective climate adaptation measures for a variety of projects and sectors.
58 Risk Stress Test (RiST) Tool	World Bank Group https://www.worldbank.org/en/topic/climatechange/brief/risk-stress-test-tool	The Risk Stress Test (RiST) tool is an Excel-based tool developed to assist with the stress testing analysis described in the methodological note 'Integrating Climate Change and Natural Disasters in the Economic Analysis of Projects: A disaster and climate risk stress methodology'. The tool highlights risks to project outcomes in the long term and identifies risks resulting from changing climate conditions, impacts of natural disasters, and changes in the frequency and intensity of natural disasters.
59 Climate Change Profiles	Government of the Netherlands https://www.government.nl/ministries/ministry-of-foreign-affairs/documents/publications/2019/02/05/climate-change-profiles	The profiles provide information on countries' vulnerabilities to climate change, their policies and commitments in place, and the climate change interventions, which are financed with international assistance. The profiles aim to assist with incorporating climate actions into development cooperation policies and activities.
60 Notre Dame Global Adaptation Initiative (ND-GAIN)	University of Norte Dame https://gain.nd.edu/our-work/country-index/	The Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index indicates a country´s vulnerability to climate change and readiness to improve resilience, as well as the ND-GAIN, a third index computed by subtracting the vulnerability score from the readiness score. This comprehensive index considers large amounts of data, covering a long-time span and has a global extent. It aims to assist governments, businesses, and communities to better prioritize investments for a more efficient response to global challenges.
61 Platform for Agricultural Risk Management (PARM)	IFAD https://www.p4arm.org/document-type/risk-assessment/ https://www.p4arm.org/document/assessing-value-chain-risks-to-design-agricultural-risk-management-strategies/	The Platform for Agricultural Risk Management aims to share knowledge and build capacity in agricultural risk management to improve vulnerable rural households' abilities to contribute to better agricultural systems. The documents guide on how to conduct an agricultural value chain risk assessment study (AVC-RAS) at the national level in a gender responsive way.
62 Climate basics, climate information service, climate risk management training guide	Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA). https://hdl.handle.net/10568/126096	This training manual comprises seven modules covering, but not limited to, information on climate variability, climate change and trends; information on climate information service (CIS), enabling environments, CIS communication methods, and the benefits of CIS; types of CIS practices and tools; and climate risk management.

63 Training manual on bundled climate-smart agriculture, climate information services and one-health technologies for priority value chains	AICCRA https://hdl.handle.net/10568/126752	This manual is intended for trainers of trainees and extension agents to enhance agricultural production in a sustainable way. The manual comprises 11 modules covering the following topics: climate information services; gender and social inclusion; the concept of One Health; biological treatment of soils and seeds; sustainable management interventions for sweetpotato, yams, maize, and cowpea; aeroponics and hydroponics; soil health management; improved tillage; and water-smart technologies.
64 Translating climate-smart agriculture policies into action: A guidebook for operationalizing climate-smart agriculture into local action planning	Alliance of Bioversity International and International Center for Tropical Agriculture (CIAT) https://hdl.handle.net/10568/114409	Implementing national policy as local-level action is challenging and requires knowledgeable technical officers and policymakers. This guidebook is based on capacity building workshops for subnational agricultural officers in Kenya. It provides lessons, activities, and a day-by-day agenda for conducting similar workshops, the outputs of which include a climate-smart agriculture (CSA) action plan and a project concept.
65 Climate-smart agriculture investment plan development guide: From concept to action	World Bank, Adaptation of African Agriculture, CIAT, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), World Agroforestry https://hdl.handle.net/10568/106262	This guide assists the user in developing a climate-smart agriculture investment plan (CSAIP). The process involves a situation analysis, the prioritization of potential CSA investments, and the identification of means for implementing and monitoring project investments. Stakeholder engagement and capacity development are key components of the process. The result is a set of evidence-based and context appropriate interventions for investors to consider.
66 Ecosystem-based adaptation	United Nations Environment Program https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation/ecosystem-based-adaptation	This website provides a briefing note series, links to toolkits, additional resources, and case studies on ecosystem-based adaptation (EbA). It also provides access to information on over 45 EbA projects located globally.
67 Adaptation Community Platform	GIZ https://www.adaptationcommunity.net/	Adaptationcommunity.net provides information on applying approaches, methods and tools that facilitate the planning and implementation of adaptation action. Information, online sessions, and training are offered on nine topics comprising: climate services, comprehensive climate risk management, the National Adaptation Plan (NAP) process, mainstreaming of adaptation, ecosystem-based adaptation (EbA), agroecology, climate change and migration, private sector adaptation and monitoring and evaluation.

68 Climate-smart agriculture training manual for training of trainers	GIZ https://www.adaptationcommunity.net/	This training manual provides information for government extension officers and lead farmers to enable them to train farmers on climate-smart agriculture (CSA) technologies, innovations, and management practices. The manual enables an understanding of the concept of CSA and associated technologies and practices. It teaches of context specific CSA application through adapting technologies, practices, and solutions to suit different locations in Kenya. It emphasizes the importance of gender and social inclusion.
69 Climate Change Knowledge Portal (CCKP)	World Bank Group https://climateknowledgeportal.worldbank.org/about	The Climate Change Knowledge Portal (CCKP) is the hub for climate-related information, data, and tools for the World Bank Group. It provides global data on historic and future climate impacts and vulnerabilities as well as disaster risks, and socio-economic factors. The data can be explored via national, subnational and watershed views. The data is also synthesized in easily accessible Climate Risk Country Profiles which describe sector-specific climate change impacts.
70 Participatory Integrated Climate Services for Agriculture (PICSA)	University of Reading https://cgspace.cgiar.org/handle/10568/68687	The Project aimed to strengthen the capacity of targeted CCAFS partners and stakeholders, and to enhance access to climate information services and validated climate-smart agriculture technologies in the eligible countries in Africa. With the support of AICCRA project, farmers and livestock keepers would be able to better anticipate climate-related events and take preventative actions, with better access to climate advisories linked to information about effective response measures.
71 CCAFS Regional Agricultural Forecasting Toolbox (CRAFT)	AICCRA https://aiccra.cgiar.org/news/craft-tool-helps-ethiopian-experts-predict-crop-yields-improve-early-warning-decisions	CRAFT addresses the lack of accessible tools that integrate seasonal climate forecasting and crop modeling to meet the needs of farmers, scientists, and policymakers through open-source platforms tailored to user needs. This makes the tool flexible and adaptable to various end-users.
72 Gender climate change and agriculture support program training of trainers	AUDA-NEPAD https://hdl.handle.net/10568/126014	The gender climate change and agriculture support program (GCCASP) is meant to be used as a CSA training tool and as a component of the process of improving trainers' and smallholder farmers' capacity to merge CSA practices, innovations, and knowledge by designing and implementing customized training courses at both levels.
73 NextGen Agricultural Drought Monitoring and Warning System (NADMWS)	AICCRA https://aiccra.cgiar.org/news/aiccra-ethiopia-launches-agricultural-drought-monitoring-and-warning-platform	The NextGen Agricultural Drought Monitoring and Warning System (NADMWS) is meant to monitor agricultural areas or 'hotspots' with a high likelihood of water stress at the national, regional, zonal and woreda (district) levels.

74 FEWS NET	USAID https://fews.net/	FEWS NET provides timely, accurate, evidence-based, and transparent early warning information and analysis of current and future acute food security in 30 world's most food insecure countries. It informs decisions on planning and responding and reporting on humanitarian food crises. FEWS NET and its partners continue to monitor increasingly complex factors affecting food security, such as weather and climate, conflict, agricultural production, markets, and nutrition. FEWS NET provides integrated food security analysis that predicts outcomes 6-12 months ahead.
75 KAOP (Kenya Agricultural Advisory Platform)	KALRO http://www.kaop.co.ke/	
76 Picture-Based Advisories (PBA)	IFPRI https://www.ifpri.org/blog/developing-and-implementing-picture-based-advisories-pba-farmers-kenya#:~:text=Advisories%20are%20based%20on%20any%20issues%20observed%20in,and%20current%20issues%20experienced%20by%20other%20area%20farmers.	PBA is designed to deliver advisory messages by local agronomic experts for farmers participating in PBI based on issues observed in pictures submitted by farmers. Each advisory message is sent through two channels, an incoming advisory tab on a smartphone app and an SMS text.

Summary and conclusion

There is an urgent need for African food systems and livelihoods to strengthen their resilience and adapt to climate change. Addressing climatic shocks will require capacity building of national stakeholders in adaptation planning. A fundamental step towards building such capacity is the careful identification and prioritization of tools and frameworks for adaptation planning and promoting their widescale use in the continent.

The 'Facilitating Knowledge Management for Adaptation Planning in Africa' project, which is funded by the Global Center on Adaptation is enhancing the resilience of farming systems and livelihoods to climate change through wide-scale use of suitable adaptation planning tools. To reach this goal, the project is (1) reviewing existing frameworks, tools, and methodologies and assess their potential and effectiveness for adaptation planning, and (2) promoting wide-scale dissemination of adaptation planning frameworks, tools, and methodologies through enhanced organizational and individual capacity for applying the frameworks, tools, and methodologies.

Consistent with these objectives, this study produced an inventory of adaptation planning tools and frameworks. The identified tools and frameworks were classified into nine categories including tools for adaptation tracking; tools and frameworks for monitoring climatic shocks, forecasting and early warning, and dissemination of climate information services; adaptation support tools and frameworks; modeling and simulation tools; land use planning and conservation tools; natural resource management tools; knowledge exchange platforms; climate-smart agriculture prioritization tools and frameworks; and climate risk and vulnerability assessment tools and frameworks. The inventory provides a detailed description of each tool as well as a summary matrix.

Generally, we find that while several adaptation planning tools and frameworks exist, the awareness and knowledge of national stakeholders about these tools seems low. Consequently, their use by national stakeholders for adaptation planning is limited. Therefore, there is need for investment and efforts to promote widescale dissemination of the tools and frameworks most applicable for adaptation planning in Africa. These investments and efforts should be intentional.

As the next steps, discussions with national stakeholders to evaluate the tools and identify those prioritized for adaptation planning would be important. Subsequent efforts will target dissemination through webinars and communication products including technical briefs and blogs.

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