منظمة الأغذية والزراعة للأمم المتحدة
联合国粮食及农业组织
Food and Agriculture Organization of the United Nations
Organisation des Nations Unies pour l'alimentation et l'agriculture
Продовольственная и сельскохозяйственная организация Объединенных Наций
Organización de las Naciones Unidas para la Alimentación y la Agricultura

Viale delle Terme di Caracalla, 00153 Rome, Italy Fax: +39 0657053152 Tel: +39 0657051 www.fao.org

Our Ref.: Your Ref.:

Submission by the Food and Agriculture Organization of the United Nations (FAO) on issues related to agriculture, as requested in the conclusions of SBSTA 40 (FCCC/SBSTA/2014/L.14, Item 8, Paragraphs 3(b) and 4). Parties and admitted observer organizations have been invited to provide their views on issues relating to the conclusion that SBSTA would undertake scientific and technical work in *"assessment of risk and vulnerability of agricultural systems to different climate change scenarios at regional, national and local levels, including but not limited to pests and diseases"*.

FAO welcomes the opportunity to provide views on the "assessment of risk and vulnerability of agricultural systems to different climate change scenarios at *regional, national* and *local* levels, including but not limited to pests and diseases". FAO wishes to underline the importance of this topic in its support to countries in relation to their adaptation policies and programmes, including the preparation of National Adaptation Plans (NAPs). Based on its work with countries, FAO has identified seven principles to guide the design and implementation of risk and vulnerability assessments in the agricultural sectors (including crops, livestock, fisheries and aquaculture and forestry) to different climate change scenarios, as well as some knowledge gaps. Considering the importance of the topic, FAO proposes that further work be conducted under the UNFCCC.

PRINCIPLES

Building upon its experience in this field, FAO proposes the following key principles for designing and conducting assessments of risk and vulnerability of agricultural systems to different climate change scenarios:

1) **Assessments should be linked to concrete development goals and actions that result in the robust adaptation of food insecure vulnerable populations, taking into account uncertainties in climate change scenarios.** Assessments should be designed and conducted as the first step leading to policy action and implementation planning, while acknowledging that assessments may also be undertaken for both awareness-raising as well as methodological advancement. Successful risk and vulnerability assessments should identify policy and development goals with the wide participation of different stakeholders, developing a common understanding of which assessments are required.

Assessments should guide the robust adaptation of food insecure, vulnerable populations, considering uncertainties in climate change scenarios. Adaptation strategies should be able to address many different plausible climates and outcomes, given the large uncertainties in climate projections. For example, scenario-based assessments allow the outcomes of different adaptation options under different climate change scenarios to be explored.

2) **The information needs of stakeholders, as well as key risk and vulnerability questions that contribute to policy objectives should be clearly defined.** Defining risk and vulnerability questions helps stakeholders agree upon a risk/vulnerability assessment framework, the methodologies to be employed, and the tools and data/information necessary for the assessment to be conducted. Vulnerability questions ask: *What are the hazards of concern? Who/what is vulnerable to what? What impacts and risks need to be addressed? At what level?* More specific examples include:

- How are food security objectives vulnerable to (threatened by) climate change at national or regional levels?
- How are agricultural sector development plans vulnerable to climate change at local level?
- How vulnerable are specific crops, species or production systems to climate change?
- How are agricultural sector-dependent communities vulnerable to climate change?

Assessment frameworks should account for the different needs of end users.

3) **Vulnerability should be contextualized within the current social, economic, environmental and institutional state of a system.** Climate change is one among many risks and drivers of change for food insecurity. It may be an amplifier of existing vulnerabilities. Its compounded effects may be difficult to single out from other drivers, or to clearly quantify and predict. Vulnerability to climate change should be seen in the context of existing broader socio-economic and environmental conditions.

4) **Assessments should be evidence- and science-based, while adopting a multi-stakeholder approach, including the views of local farmers, fishers and foresters.** Assessments should be based on the best available scientific information (methodologies, tools, models, and data), making use of model-based methodologies as well as participatory, perceptions-based methodologies. In order to ensure accountability, replicability and transparency, established and robust methodologies should be selected, while allowing for uniqueness inherent to each context.

Stakeholder involvement in the process is key to a successful assessment that can inform adaptation policy processes. Stakeholders should be identified and their roles and existing capacities evaluated. They should be consulted to elicit their climate change risk and vulnerability questions and information needs. When working at the local level, the perceptions of farmers, foresters and fishers should be considered and verified. By the nature of agricultural systems, assessments need to be multi-disciplinary, encompassing biophysical processes and socio-economic dimensions.

5) **Assessments should be an iterative, participatory and multi-stakeholder process with periodic revisions to incorporate new information.** Understanding climate change risks and vulnerabilities is an evolving science, and socio-economic and environmental conditions continue to change. Therefore, assessments need to be revised periodically with new information. This enables climate change adaptation strategies to make adjustments for achieving the development goals agreed to by stakeholders. The results of assessments should be communicated through context-relevant channels to all stakeholders, including vulnerable farmers, fishers, foresters and dependent communities.

6) **Assessments should identify opportunities alongside risks, under different climate change scenarios and for different systems.** Climate change can bring opportunities as well as risks. A risk and vulnerability analysis can help identify conditions in which opportunities may (or may not) be taken advantage of, or identify cases where risks will affect systems (sectors, dependent communities, economies, natural systems, etc.) differently. Scenarios of multiple hazards may also need to be considered.

7) **Assessments should be incorporated in the monitoring and evaluation of programmes and projects.** Risk and vulnerability assessments provide baseline information for determining adaptation actions and assessments under different climate change scenarios. Effectiveness of adaptation programmes and projects should be monitored and evaluated against such vulnerability baselines.

GAPS IN CURRENT KNOWLEDGE

Areas for further work include the following:

- Assessments of risk/vulnerability/impacts to climate change under different scenarios that identify and implement adaptation options. More research on assessments that facilitate stakeholder identification of good adaptation practices under different climate change scenarios is necessary.
- Downscaling models to support assessments at different scales and increased accuracy at those scales.
- Better incorporating the use of long-term predictive models with the immediate need to adapt.
- Combining farmer/fisher/pastoralist/forester and other stakeholder experiences and local knowledge with model-based information to arrive at appropriate recommendations for adaptation actions and interventions.
- Linking the social systems with the biophysical processes of climate-induced changes. It is necessary to acknowledge and improve the knowledge of social-ecological climate drivers and vulnerabilities of agriculture, forest and fisheries systems (e.g. indirect impacts on livestock through natural vegetation; direct impacts on

fish species; indirect impacts on forest-dependent communities; and direct impacts on production and post-harvest infrastructure, safety at sea, access to markets).
- Understanding how climate change adaptation actions in one subsector may have risk and vulnerability implications for other subsectors (e.g. upstream dam construction in large catchments affecting agriculture, fisheries and aquaculture downstream, often across borders).

RECOMMENDATIONS

Considering the importance of the topic, FAO recommends that further work be conducted under the UNFCCC. Several options could be considered by Parties in this regard in collaboration with the Nairobi Work Programme, the Adaptation Committee and the Least Developed Countries Expert Group:

- Providing support for more detailed *regional, national* and *local* risk and vulnerability assessments.
- A Technical Expert Meeting on agriculture and food security could be conducted under the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP).
- The Adaptation Committee may consider establishing a workstream on risk and vulnerability of agricultural systems to climate change scenarios.
- The establishment of a dedicated workstream under the Nairobi Work Programme could be considered, encompassing:
  - Improved use of data, information and knowledge on vulnerability, impacts and adaptation related to agriculture, forestry and fisheries and food security at the *regional* and *national* levels for improved adaptation planning.
  - *Regional* workshops for scientific knowledge-sharing and validation with policy makers from the climate change and agricultural sectors, in support of evidence-based adaptation actions at *regional* and *national* levels to address risk, reduced vulnerability and to increase the resilience of agricultural systems to long-term climate change.
  - Periodic reviews of *regional, national and local* climate change impact and vulnerability assessments on food systems, including food security and nutrition, related biophysical and socio-economic impacts, and pests and diseases.
- Preparing a guidance document on how to design and conduct risk and vulnerability assessments of agriculture, fisheries or forestry systems to climate change, which could further support countries in their NAPs preparation.

FAO's work in these areas can facilitate the above-mentioned activities. In the Annex below, some examples of FAO's work are provided.

REFERENCES

Barsley, W., De Young, C & Brugère, C. 2013. Vulnerability assessment methodologies: an annotated bibliography for climate change and the fisheries and aquaculture sector. FAO Fisheries and Aquaculture Circular No. 1083. Rome, FAO. www.fao.org/docrep/018/i3315e/i3315e.pdf

Brugere, C. & De Young, C., *In preparation.* Assessing climate change vulnerability in fisheries and aquaculture: Available methodologies and their relevance for the sector. FAO Fisheries and Aquaculture Technical Paper. Rome, FAO.

Cinner, J., McClanahan, T., Wamukota, A., Darling, E., Humphries, A., Hicks, C., Huchery, C., Marshall, N., Hempson, T., Graham, N., Bodin, Ö., Daw, T. & Allison, E. 2013. Social-ecological vulnerability of coral reef fisheries to climatic shocks. FAO Fisheries and Aquaculture Circular No. 1082. Rome, FAO. 63 pp. www.fao.org/docrep/018/ap972e/ap972e.pdf

FAO, 2012. Annex 2: Approaches to rapid assessments of impacts of climate variability and climate change on agriculture in the project area. Incorporating climate change considerations into agricultural investment programmes: a guidance document. www.fao.org/docrep/016/i2778e/i2778e.pdf

FAO-OECD, 2012. Building Resilience for Adaptation to Climate Change in the Agriculture Sector, Rome. www.fao.org/docrep/017/i3084e/i3084e.pdf

FAO, 2012. Potential impacts of climate change on food security in Mali. www.fao.org/docrep/016/i2856e/i2856e.pdf

FAO, 2013. Climate change guidelines for forest managers. FAO Forestry Paper No. 172. www.fao.org/docrep/018/i3383e/i3383e.pdf

FAO, 2013. Report of the FAO/PaCFA Expert Workshop on Assessing Climate Change Vulnerability in Fisheries and Aquaculture: Available Methodologies and their Relevance for the Sector, Windhoek, Namibia, 8–10 April 2013. FAO Fisheries and Aquaculture Report No. 1047. Rome. 29 pp. www.fao.org/docrep/018/i3357e/i3357e.pdf

FAO, 2013. Climate-Smart Agriculture Sourcebook. Module 18 Assessment, Monitoring and Evaluation. www.fao.org/climate-smart-agriculture/72631/en

FAO, 2015 *(forthcoming)*. Climate change and food systems: global assessments and implications for food security and trade.

Sumner, J., Ross, T., Ababouch, L., 2004. Application of risk assessment in the fish industry. FAO Fisheries Technical Paper. No. 442. www.fao.org/docrep/007/y4722e/y4722e00.htm

ANNEX: CASE STUDIES

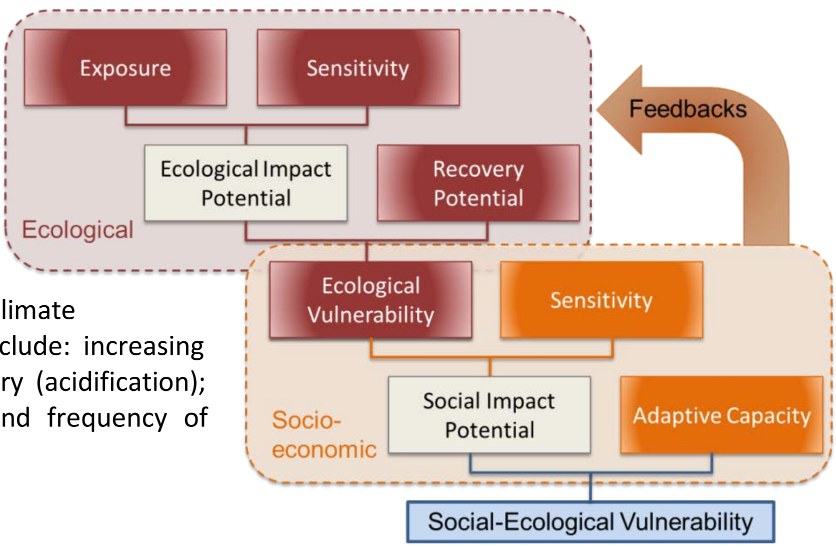
This Annex contains five examples of different vulnerability and risk questions, scales, methodologies, and principles from ongoing FAO projects in different subsectors and at the different levels of intervention requested (*regional, national* and *local*).

Case 1: Social-ecological vulnerability of coral reef fisheries to coral bleaching in Kenya

Purpose of assessment: This study piloted a vulnerability assessment method to help countries, development agencies and their staff, researchers and fisheries professionals in understanding how to define and measure vulnerability within complex fisheries systems, using risks of coral reef bleaching in Kenyan reef-dependent fishing communities as an example. Ultimately, the scope of this work was to improve resilience of fisheries systems and dependent communities to multiple drivers of change, including climate change and ocean acidification.

Vulnerability question: What is the social-ecological vulnerability of coral reef fisheries to climate change-induced coral bleaching?

Definition and interpretation of vulnerability: The IPCC model of vulnerability was extended to capture ecological vulnerability nested within social vulnerability, as illustrated on the right.



Context: In addition to a range of direct threats such as siltation, overfishing and coral disease, coral reefs are now threatened by climate change. Climate impacts on coral reefs and associated fisheries include: increasing seawater temperatures; changes in water chemistry (acidification); changes in seasonality; and increased severity and frequency of storms, which affect coral reef ecosystems as well as fisheries activities and infrastructure. Coral bleaching and associated coral mortality as a result of high seawater temperatures is one of the most striking impacts of climate change that has been observed to date. As warming trends continue, the frequency and severity of bleaching episodes are predicted to increase with potentially fundamental impacts on the world's coral reefs and on the fisheries and livelihoods that depend on them.

Findings: The analysis conducted combined ecological vulnerability (social exposure), social sensitivity and social adaptive capacity into an index of social-ecological vulnerability to coral bleaching. All three components of vulnerability varied across the sites and contributed to the variation in social-ecological vulnerability. Comparison over time showed that adaptive capacity and sensitivity indices increased from 2008 until 2012 owing to increases in community infrastructure and availability of credit. Disaggregated analysis of how adaptive capacity and sensitivity varied between different segments of society identified the young, migrants and those who do not participate in decision-making as having both higher sensitivity and lower adaptive capacity and, hence, as being the most vulnerable to changes in the productivity of reef fisheries.

Reference (for full data and methods): Cinner, J., McClanahan, T., Wamukota, A., Darling, E., Humphries, A., Hicks, C., Huchery, C., Marshall, N., Hempson, T., Graham, N., Bodin, Ö., Daw, T. and Allison, E. 2013. Social-ecological vulnerability of coral reef fisheries to climatic shocks. FAO Fisheries and Aquaculture Circular, No. 1082. FAO, Rome.

Case 2: Baseline and drought scenario for the period 2012-2030 and impacts on pastoral systems in Sub-Saharan Africa

Livestock is key to food security in Africa but also to rural development as a whole, especially in marginal lands. In Sub-Saharan Africa, more than one person out of two keeps some livestock and one out of three can be considered a resource-poor livestock keeper (FAO, 2012). Africa as a whole is one of the most vulnerable regions to climate change because of its exposure, sensitivity and lower capacity to cope (Niang et al., 2014). Increasing temperatures and changes in precipitation are very likely to reduce livestock productivity, directly but also indirectly through impacts on feed crops and forages. Pest, weed and disease pressures are also expected to increase (Thornton et al., 2009). Early warning systems specific to livestock are available (e.g. in East Africa), but there is a significant lack of information and data to guide interventions to move from an emergency type of response to policies building resilience. IPCC Working Group 2 recognizes that very few impact assessments are available for livestock and that almost no framework integrating biophysical data and management options exist.

FAO, the World Bank, CIRAD, IFPRI and Action Contre la Faim developed a methodological framework to assess livestock production under climatic constraints. This framework was tested in the African drylands to assess the impact of climatic patterns and interventions scenarios on livestock production and illustrate the potential of livestock to support adaptation to climate change in marginal lands. Interventions assessed include improvement of animal health (e.g. through vaccination, antiparasitic treatment) and stratification of production (fattening of young bulls outside the drylands). The framework is a first attempt at coupling biophysical data, both on natural vegetation and livestock, with management interventions and relies on the integration of four of modeling tools: BIOGENERATOR developed by Action Contre la Faim, the Global Livestock Environmental Assessment Model (GLEAM) developed by FAO, IMPACT developed by IFPRI and MMAGE, a package developed by CIRAD.

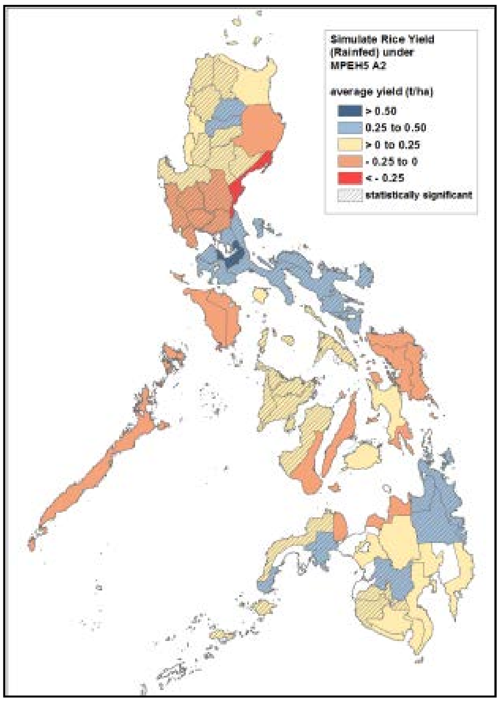
Major attention was given to the assessment of the volume and quality of feed supplies in the drylands and the degree to which they are expected to meet the animal requirements under different climatic and intervention scenarios, for the period 2012-2030. A methodology was developed to assess supply and quality of feed resources, from the biomass available from grass, trees and crops to the feed usable and accessible for the animals.

Results show that 2.5 times more feed resources are needed in a baseline 2012-2030 scenario with a similar climate to the past (1998-2011), and 3.5 times more feed is needed in case of drought. They also show that there is a potential for livestock growth if feed resources are made accessible, which calls for interventions in animal mobility (corridors, security, border regulations, health, tenure), feed management (storage, processing, transport) and stratification of production to reduce pressure in arid areas. Interventions can significantly increase the output of livestock products in the African drylands (5 percent to 20 percent) if accessibility to feed is improved. Shocks brought on by climate-driven variability on livestock production can be buffered by livestock production through animal movements, adjustments in feed baskets, health interventions and animal offtake for market.

Important data caveats were identified that should be addressed to support better impact assessments in livestock production: livestock technical performance data, natural vegetation accessibility for animal feed, animal mobility, characterization of feed resources and their quality, and official statistics of livestock numbers.

Case 3: AMICAF and MOSAICC: An inter-disciplinary assessment of impact of climate change on agriculture and food insecurity vulnerability in support of climate change adaptation planning (Morocco, Philippines, Peru)

The Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security (AMICAF) project aims to build the capacities of countries to produce evidence-based information on impacts of climate change on the agricultural sectors, and resulting vulnerability to food insecurity for long-term climate change adaptation planning. The project is in operation in the Philippines and Peru.



The project uses, amongst others, the Modelling System for Agricultural Impacts of Climate Change (MOSAICC) tool, an interdisciplinary climate change impact assessment tool first piloted in Morocco, with modules for climate downscaling, crop modelling, water resources modelling, and economic modelling. The selected models are robust and suited for sub-optimal data quality and availability in developing countries while ensuring scientific quality. A team of national institutes/universities is formed and an extensive training programme is provided so that national experts can carry out assessments for their own country using MOSAICC. The project team and its experts regularly meet with Ministry of Agriculture and associated government offices to respond to their needs for climate change risk and vulnerability information. The tool is designed for national-scale assessment with sub-national disaggregation, enabling policy makers to understand differentiated levels of risks among provinces within the country. MOSAICC employs a top-down vulnerability framework, starting from coarse resolution climate projections from global climate models to local-scale impacts in terms of changes in crop yields, river discharge, and gross domestic product. A set of eight different global climate models and two representative concentration pathways are available for statistical downscaling of climate projections so that uncertainties in projected impacts can be accounted for. The simulations run on a centralized server so that the results can be shared and validated by peers to ensure transparency and replicability. The project complements MOSAICC with an agricultural market model to derive impacts on farmgate prices.

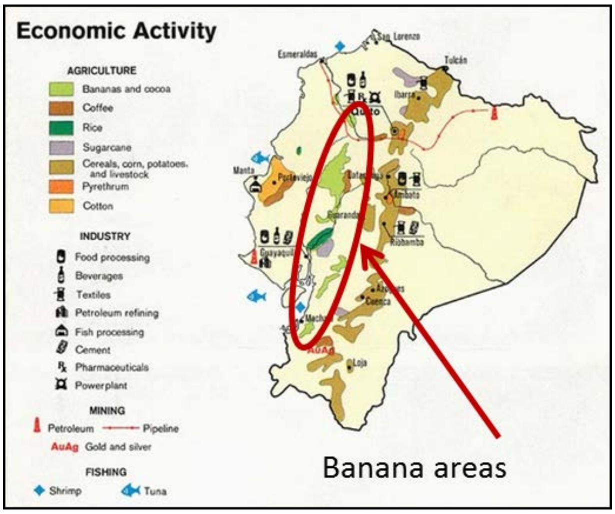
The AMICAF project also uses a bottom-up approach to vulnerability assessment, in order to characterize vulnerability to food insecurity at the household level under a changing climate. The econometric methodology explores and identifies the channels through which changes in climate pass through at the household/farm level, identifies and maps vulnerable groups (profiling), considers the adaptive capacity options of farmers (agronomic and economic level), and finally explores the efficiency of different policy tools. The analysis makes use of extensive data sets on household surveys on nutrition, family income, expenditure, and other socio-economic indicators to characterize vulnerable groups of people.

Figure: Projected rainfed rice yield change from the present time to a future period in a GCM and an emission scenario in the Philippines.

Further reading: www.fao.org/climatechange/amicaf and www.fao.org/climatechange/mosaicc

Case 4: Economic and biophysical assessments of climate change impact on the banana sector and the impacts of climate on pests and diseases for tropical crops in Ecuador

Ecuador's banana industry is the country's largest agricultural export sector, employing 10 percent of the total population. An inter-disciplinary biophysical and economic analysis was conducted to enable the transition of the sector towards higher productivity and increased sustainability. The analysis took into account the likely impacts of climate change on future production yields, water availability and changing dynamics of pests and diseases. A key concern in terms of banana production is the high level of pesticide uses to maximize yields. The economic analysis focused on costs (driven by labour and pesticide inputs) and market structures, as well as on the uneven distribution along the value chain, which is creating significant social inequality. The biophysical analysis covered: (i) the carbon footprint and GHG emissions associated with banana production, including the stages from transportation through to consumption; (ii) the climate change impact on banana suitability in Ecuador; (iii) the implications of the changing climate parameters on the dynamics of pests and disease; and (iv) the likely changes that will need attention immediately and in the future, to ensure the continued economic viability of a system that is vital to Ecuador's agricultural economy. From a socio-institutional perspective, a study was made of Ecuador's social policies to ensure a fairer distribution of returns to stakeholders across the banana value chain, especially with regard to smallholder farmers and banana plantation workers, who play an important role as constituents within Ecuador's main agricultural industry. The socio-institutional analysis included the issue of governance, relating to the banana value chain, not only within Ecuador (labourers, producers, exporters), but also beyond its borders (consumers).



This inter-disciplinary assessment of the banana sector aimed to provide the evidence needed to articulate a climate-compatible strategy and to help guide Ecuador's existing banana policy with respect to the responsible environmental management of pesticides as well as Ecuador's social responsibility towards its workers, including fair wage distribution. The impacts of climate change have been found to be broadly favourable to future banana production in Ecuador. However, the impacts of climate change on the dynamics of pests and diseases in Ecuador will require further research, especially as climate change may increase the aggressive impact of current pests and result in the emergence of new diseases or pest strains. Collaborative research among banana producing countries and increased research capacity is recommended.

Reference: FAO, 2015 *(forthcoming)*. Ecuador's banana sector under climate change: An economic and biophysical assessment to promote sustainable and climate-compatible industry.

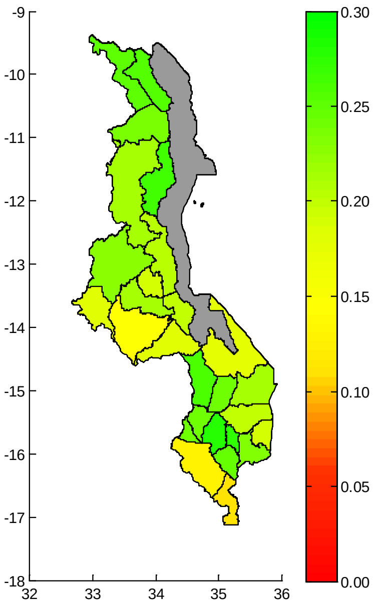
Case 5: Assessing vulnerability to climate change: the role of diversification in Malawi

Malawi is one of the world's most vulnerable countries to the adverse effects of climate change. FAO's Economics and Policy Innovations for Climate-Smart Agriculture (EPIC) programme (www.fao.org/climatechange/epic) conducted research funded by the European Commission to better understand the impacts of climate variability and to develop strategies to support farmers' capacity to cope with this challenge.

Rationale for assessment: Diversification in rural environments is a dynamic adaptation process in response to threats and opportunities. The assessment set out to understand the drivers and the impacts of diversification strategies on household welfare under increased exposure to climate risk by: a) Analyzing how climate patterns affect diversification choices; b) Testing whether climate variability affects households' vulnerability to poverty; c) Testing whether policy-relevant mechanisms can be effective means of mitigating the negative welfare effects of local climate variability via diversification strategies.

Three main types of data were used: 1) Nationally representative socio-economic household data (IHS3); 2) Historical satellite data on rainfall and temperature (NOAA and ECMWF); 3) Primary data on institutions. Diversification is measured using a Margalef index of cropland and income diversity, whereas vulnerability to poverty is measured by the expected level and variability of consumption.

Drivers of diversification and role of climate: Results indicate that income and cropland diversification is higher in environments with greater long-term climate variability, and that higher long-term mean rainfall is associated with greater income diversification. Short-term anomalies, on the other hand are associated with less income diversification.



Wealth is associated with less crop diversification, suggesting specialization. However, high agricultural assets and larger land areas lead to higher income and cropland diversification. Institutional factors affecting diversification include extension, which leads to higher diversification, and social safety nets, which tend to reduce cropland diversification.

Diversification and climate effects on poverty: Project findings indicate that income and crop diversification reduce vulnerability to poverty. On the climate front, higher long-term mean rainfall is associated with higher consumption whereas vulnerability to poverty increases when short-term shocks occur. Access to institutions (extension, credit and social safety nets) increase consumption and fertilizer subsidies reduce vulnerability to poverty.

Policy Implications: Income diversification is an effective means of coping with climate variability. Extension and fertilizer subsidies have strong positive effects on income diversification; policies should be oriented towards this objective. Safety net payments could be targeted to those affected by shocks so as to avoid reductions in consumption and increased vulnerability to poverty.

Figure: Income diversification in Malawi.

Reference: Asfaw, S., McCarthy, N., Cavatassi, R., Paolantonio, A., Mulubrhan, A., Lipper, L., 2015 *(forthcoming).* Diversification, Climate risk and Vulnerability to Poverty: Evidence from Rural Malawi., ESA Working Paper, Food and Agriculture Organization of the United Nations (FAO).