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Submission by the Food and Agriculture Organization of the United Nations (FAO) to the United Nations Framework Convention on Climate Change (UNFCCC) on Issues relating to agriculture: adaptation measures

In response to the UNFCCC call for submission on "issues relating to agriculture", as requested in the conclusions of **SBSTA 40 (FCCC/SBSTA/2014/L.14, Item 8, Paragraphs 3 (c) and 5)**, FAO is pleased to submit its views and proposals relating to workshop topic C **"Identification of adaptation measures, taking into account the diversity of the agricultural systems, indigenous knowledge systems and the differences in scale as well as possible co-benefits and sharing experiences in research and development and on the ground activities, including socioeconomic, environmental and gender aspects"**.

FAO welcomes the organization of the four UNFCCC workshops on "issues relating to agriculture" and wants to underline the importance of this dialogue. FAO wishes to refer to its two submissions[1] on the workshop topics A[2] and B[3] held at SBSTA 42, and the FAO submission on the workshop topic D for SBSTA 44 as well as the submission to the launch of the Technical Examination process on Adaptation for the period 2016–2020 (A-TEP).[4]

The preamble of the Paris Agreement makes specific reference to "safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change". In line with its mandate, FAO considers the adaptation of agriculture as part of this broad objective of safeguarding food security and nutrition and ending hunger. This requires consideration of the impacts of climate change on food security and nutrition in its four dimensions (availability of food, access to food, food utilizations and stability[5]). It also requires particular attention to be devoted to the most vulnerable countries and regions, arid and semi-arid areas, coastal areas, mountainous areas, land locked countries and small island states. In addition, it refers to the most vulnerable populations, poor, indigenous peoples and women dependent on ecosystems and agriculture for their livelihoods.

FAO adopts a holistic approach to the adaptation of agriculture, as shown in the FAO-Adapt Framework[6] and in its technical support to implement the Sendai Framework for Disaster Risk Reduction (SFDRR) in agriculture, fishery and forestry sectors[7]. In the recent publication "Climate Change and Food Security: Risks and Responses"[8] FAO (2016a) described the cascading impacts of climate change on agriculture and food security. A range of physical, biological and biophysical impacts on ecosystems and agro-ecosystems, translate into impacts on agricultural production. This has an effect on the quantity, quality and cost, influencing the income of farm households and the purchasing power of non-farm households. All four dimensions of food security and nutrition are impacted by these effects and need to be addressed.

The challenges that climate change poses to agriculture are very specific. They directly threaten food provision as well as the basis of the livelihoods of a large portion of the world's population. In this respect, FAO would like to underline five key points:

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[1] http://www.fao.org/climate-change/international-fora/submissions/2014/en/
[2] http://unfccc.int/land_use_and_climate_change/agriculture/workshop/8936.php
[3] https://unfccc.int/land_use_and_climate_change/agriculture/workshop/8935.php
[4] http://unfccc.int/documentation/submissions_from_observers/items/7481
[5] http://www.fao.org/docrep/013/al936e/al936e00.pdf
[6] http://www.fao.org/climatechange/fao-adapt/en/
[7] Also including crops, livestock and aquaculture
[8] http://www.fao.org/3/a-i5188e.pdf

- **Climate variability and climate change** affecting the agriculture sectors **undermines** the already vulnerable situations of the world's poor and food insecure, the vast majority of whom are **farmers, herders, fishers, forest-dependent communities as well as women and indigenous people**. Adaptation measures need to be **tailored** to the most vulnerable people and at a **scale that allows for impact**.

- Climate change brings **a cascade of risks** from physical impacts to ecosystems, agro-ecosystems, agricultural production, food chains, income and trade, with economic and social impacts on livelihoods and food security and nutrition. **Understanding these risks**, the exposure and vulnerabilities to these risks **is key to deciding on different adaptation measures**.

- **A holistic approach** must be taken when looking at the challenges that agricultural systems have to address to ensure food security through improved productivity and resilience. **To mainstream this holistic approach**, it will be essential (i) for farmers, fishers, foresters, herders, and other stakeholders along the food chain, to see tangible advantages, including improved resistance to climate-induced challenges; and (ii) for policy-makers to design and implement supportive policy frameworks that include incentives, address climate change issues and rural development, and foster synergies between multiple benefits through the sustainable transformation of agriculture.

- The agriculture, forestry and land use sectors are prominent in the vast majority of the **Intended Nationally Determined Actions (INDCs)** that were submitted ahead of COP21. Of the 188 countries that had submitted INDCs as of 04 February 2016, 80 percent identified mitigation measures in the agriculture sectors.[9] Over 95 precent of countries that included an adaptation section give an important place to the agriculture sectors.[10] Close to 40 percent of INDCs reference women and gender as key considerations for the implementation of activities. As part of the INDCs, 30 countries are currently in the process of designing or finalizing their **National Adaptation Plan (NAP)** and 21 further countries intend to start the NAP process in the near future. Botswana, Costa Rica, Lesotho, Sudan, Uganda and Uruguay explicitly refer to agriculture in this regard. This provides great potential for enhanced national and sub-national climate action for the agriculture sectors to **address the urgent, medium and long term needs posed by climate change.**[11]

- **Urgent action** is needed to adapt the agriculture sectors and to enable them to play their part in national adaptation strategies. Such action needs to be supported by appropriate means.

The present submission summarizes the main findings of the paper: "Climate Change and Food Security: Risks and Responses", launched in January 2016 as a contribution to the on-going discussions under SBSTA[12] and to support the preparation of the NAPs.[13]

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[9] Mitigation – Agriculture (135 countries), Land use, land use change and forestry (143 countries) and fisheries and aquaculture (7 countries).

[10] Adaptation – Crops and livestock (123 countries), forestry (105 countries), and fisheries and aquaculture (58 countries).

[12] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

[13] FAO is supporting countries integrating agriculture in NAPs http://www.fao.org/climate-change/programmes-and-projects/detail/en/c/328984/

The study identifies **six key areas of adaptation measures** in the agriculture sectors and for food security.

- **Key Area 1: Increase resilience of livelihoods**
- **Key Area 2: Build resilience of agricultural systems**
- **Key Area 3: Managing genetic resources**
- **Key Area 4: Investing in resilient agricultural development**
- **Key Area 5: Investing in systems to assess risks, vulnerabilities and adaptation options**
- **Key Area 6: Enabling adaptation through policies and institutions**

These key areas of adaptation measures have been identified to fully address the range of possible adaptation measures considering key vulnerabilities to agriculture and food and nutrition security including environmental (e.g. in coastal zones, degraded areas, drylands and mountains), economic (e.g. populations in conflict areas, poor populations in urban and rural settings), social (e.g. female and elderly headed households) and institutional (e.g. lack of institutional capacity, people with insecure land and resource tenure) dimensions.[14] Identification of adaptation measures should be conditioned on vulnerability and risks especially focusing on risks of extreme climate events which often undermine decades of development gains. Combination of measures for disaster risk reduction and adaptation (DRR) to climate change is the way forward to build resilience.

Importantly, adaptation options need to take into account the co-benefits from adaptation responses and hence the need to sustainably increase production in order to address an increasing demand, driven by population growth and changing diets, as well as potential mitigation co-benefits. In doing so there is a need to carefully assess potential trade-offs or synergies between increased efficiency in the use of resources on one side and resilience on the other. The climate-smart agriculture (CSA) approach, which examines the synergies and trade-offs between food security, adaptation and reducing greenhouse gas emissions, can contribute by making sure that adaptation measures are not proposed in isolation. This kind of a holistic approach could improve the effectiveness of approaches to climate change and the achievement of the Sustainable Development Goals (SDGs). Adaptation in agriculture should consider commitment across sectors, and actions range from investments at different levels (field, farm, land-scape, national) and should vary from practices, institutional strengthening, provision of needs based climate information services, early warning systems, agricultural support services (inputs and technology), mainstreaming and policy support.

Annex 1: More details on the adaptation measures as per key area,

Annex 2: Examples of adaptation options in the agriculture sectors,

Annex 3: Potential gender considerations in adaptation options, and

Annex 4: Case studies providing evidence of the effectiveness of the adaptation measures

Recommendations

As shown by the previous workshops and as expressed by Parties, such technical exchanges are key to sharing information and good practices as well as to building a common understanding of the issues to be addressed in the agriculture sectors by UNFCCC. Therefore FAO suggests that Parties consider further work on issues related to agriculture under SBSTA.

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[14] Climate Change and Food Security: Risks and Responses. pp.26 http://www.fao.org/3/a-i5188e.pdf

Annex 1: Adaptation Measures per Key Area

The following text outlines **six key areas** for **possible adaptation measures** in the agriculture sectors in order to ensure food security, taking into consideration the various dimensions requested for submission C.

Key Area 1: INCREASE RESILIENCE OF LIVELIHOODS

What do we mean by resilient livelihoods in the context of achieving global food security under climate change? Resilient livelihoods are livelihoods that are resistant to climate risks and have the capacity to prevent or absorb the impact of and adapt to the changing climate and respond to disasters if they cannot be avoided. Increasing the resilience of livelihoods enables those who are poor and food-insecure to escape poverty and hunger. It gives them the capacity to invest and to adapt despite climate risks. Examples of this can be seen in case studies 1 and 2: “Farmer field schools to integrate climate resilience in Mali” and “Small-scale fisheries in South Africa use a mobile-based information management system”**.**

1.1 - Devise appropriate social protection strategies

Achieving the zero hunger goal as soon as possible requires prompt action in providing the poor with additional incomes so that they can achieve sufficient nourishment. Reducing the number of those below the poverty line may then permanently ensure access to basic food and other needs and enable more diverse and thus healthier diets with adequate micronutrients. As demonstrated in the past, social protection is an affordable investment in pro-poor growth. Appropriately designed transfers would also enable the poor to save and invest parts of their income to improve their productivity. In the short and long term, improving nutrition should in fact enable poor people to engage more productively in economic activities, which will further improve their incomes and allow them to transition out of the vicious circle of poverty[15]. There are innovative solutions available, for example linking social protection to key financial services. Another example might be linking social protection management and information systems with climate-related early warning systems to promote timely and flexible responses when severe weather events strike.

1.2 - Address gender-differentiated vulnerabilities and capacities

Gender-differentiated vulnerability is often determined by socio-economic factors, livelihoods, access to knowledge, information, services, support, resources and infrastructure. The adaptive capacity of both men and women depends on opportunities governed by the complex interplay of social relations, institutions, organizations, and policies. As “the socio-political relations between men and women affect the planning and implementation of adaptation actions”[16], and as men and women’s vulnerabilities and capacities differ[17], adaptation actions should follow gender-responsive and participatory approaches.[18] In the agriculture sectors this means, among other things, collecting and analysing sex- and age-disaggregated data on access to and use of resources, including information[19]; addressing women’s strategic needs, such as insecure land and resource tenure, to facilitate the adoption of climate-smart agricultural practices[20]; examining how institutions may perpetuate inequalities,[21] involving men and women in the conservation of biodiversity; and

[15] FAO, IFAD and WFP. (2015). Achieving Zero Hunger: the critical role of investments in social protection and agriculture. Rome, FAO.
[16] LDC Expert Group. (2015).
[17] World Bank, FAO, IFAD. (2015).
[18] Acknowledged under article 7, paragraph 5 of the Paris Agreement.
[19] Jost et al. (2015).
[20] Quisumbing and Kumar. (2014).
[21] Okali and Naess. (2013).

providing training on agricultural extension for both women and men.[22] Many adaptation practices require investments in cash, time or labour and thus are costly for households with limited access to credit and with few, mostly female working-age adults. Consequently, when designing policies and programmes in response to climate change, gender equity trade-offs need to be systematically analysed and addressed. Numerous resources are available for incorporating gender-responsive and participatory approaches into policy-making, project management and research[23] in order to target different populations' needs for climate change adaptation. An example of this can be seen in case study 3 "Increasing rural women's income through climate smart agriculture in Western Kenya".

1.3 - Conceive DRR for food and security and nutrition in the context of climate change adaptation

Building resilience requires a change in the conventional approach to disaster risk reduction and the need to prioritize the reduction and active management of risks, rather than being limited to reacting to extreme events. Field-based evidence shows that DRR is cost-effective: for every USD1 spent on DRR, USD2–4 are returned in terms of avoided or reduced disaster impacts. Yet, investment in proactive disaster risk reduction, and specifically in DRR in agriculture, is extremely low. Annually, an average of less than 5 percent of all humanitarian funding has gone to disaster preparedness and prevention, and for those countries most in need, it is less than 1 percent.

Key Area 2: BUILD RESILIENCE OF AGRICULTURAL SYSTEMS

Agricultural systems can be made more resilient at the farm/production level, throughout the supply chain, or at different landscape levels. They all have the aim of increasing the resilience of the agriculture sectors, food systems and households depending on them for their livelihoods, as well as of the resilience of the natural resource base underpinning long term food security and development. Depending on the given contexts, incremental changes can be introduced more or less easily, on shorter or longer time scales, and the impacts of those changes can take more or less time to be effective.

A primary means of increasing the resilience of agriculture-based livelihoods is through increasing and stabilizing the benefits producers obtain from their production systems. Depending on individual circumstances, individual farmers can adopt a suite of measures to adapt. Please refer to case study 1 "Farmer field schools to integrate climate resilience in Mali".

2.1 - Crop systems

Adaptive changes in crop management – especially planting dates, cultivar choice and sometimes increased irrigation – have been studied to varying extents, and in many regions farmers are already adapting to changing conditions, many of them being changes made to existing climate risk management practices. Adaptive changes in crop management have the potential to increase yields by an average of 7–15 percent[24], though these results depend strongly on the region and crop being considered: for instance, according to the IPCC (2007), responses are dissimilar between wheat, maize and rice, with temperate wheat and tropical rice showing greater potential adaptation benefits.

2.2 - Livestock and pastoral systems

Regions identified as the most vulnerable to climate change, such as Sub-Saharan Africa and South Asia, are also regions where farmers and rural communities rely the most on livestock for income and livelihood, and where livestock is expected to contribute more to food security and better nutrition. Traditionally, livestock

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[22] Aguilar et al. (2015).
[23] See UNDESA, UN Women, UNFCCC, 2015; UNDP, 2010; FAO and CCAFS, 2012.
[24] Müller and Elliott (2015).

keepers have been capable of adapting to livelihood threats and, in some situations, livestock keeping is itself an adaptation strategy, in particular in pastoral communities where livestock have always been the main asset to face harsh climatic conditions.[25] Livestock can be used as a diversification and a risk management strategy in case of crop failure. Moreover, in some regions, switching from crop to mixed crop–livestock or to livestock systems will be a key adaptation strategy.[26]

Livestock's adaptive capacity depends on the production system including choice of species and breeds, the availability/adaptability of alternative feed resources, the accessibility of animals (health/extension services), the type/efficiency of response to outbreaks (surveillance, compensation schemes etc.) and the household wealth status.[27]

A range of adaptation options are available for livestock production. They exist on different scales: animals, feeding/housing systems, production systems and institutions. They also differ between small scale livestock production with low market integration and large scale production with high market integration. In particular, breeding schemes, feeding strategies, disease control and grazing management are considered as key adaptive responses.

Despite the key role of livestock in building resilience, there is a lack of assessments to inform decision makers and provide evidence for policies to support adaptation. In particular, frameworks and methodologies for assessing livestock productivity under climate constraints that integrate biophysical data (e.g. vegetation, feed resources, and animal requirements) with management options (e.g. technical and policy interventions) are missing. Information and data to support and guide interventions in the sector, and move from an emergency type of response to policies supporting resilience building are therefore missing. An example of this can be found in case study 4 "Livestock as a tool for adaptation in the drylands".

2.3 - Forests

Over a billion people, a large proportion of whom are poor and live in fragile environments, are wholly or partly reliant on forests and trees for their livelihoods. These are the same people and environments that are highly vulnerable to climate change. The use of forests and trees to reduce risk and help vulnerable people adapt to climate change, and the adjustment of forest management plans and practices to increase forest resilience and adaptability should both be considered as elements of countries' climate change adaptation strategies.

Forests and trees also provide a range of ecosystem services that support food production and contribute to food security and people's wellbeing in other ways. At household level, forests and trees play important roles in livelihood resilience in the face of climate change, including as:

- Providers of ecosystem services, often from agroforestry systems, that furnish protection against wind and erosion damage, provide shade, and improve soil fertility.
- Sources of products important for household use and income diversification for farm households and rural families. Agroforestry and use of wood and non-wood products sourced from forest and trees off-farm are widespread practices that can increase income stability through product diversification.
- Sources of employment (particularly important where farming and other rural livelihoods are no longer viable).

[25] IUCN, 2010; Scoones, 1996; Ashley and Carney, 1999.
[26] Jones and Thornton, 2009.
[27] ICEM, 2013.

- Safety nets to turn to as sources of food or products for sale in times of emergency. The importance of forests as safety nets in times of natural disasters (e.g. floods and droughts) or civil unrest is well documented.[28] It is important to keep the safety net option open (i.e. not restricting the access of vulnerable people to forests when needed for survival).

At landscape level, forests and trees contribute to resilience and adaptive capacity through the provision of a wide range of ecosystem services. In response to risked posed by climate change and extreme events, forest management practices can be adjusted to increase the provision of ecosystem services that will decrease vulnerability. Among others, these include protection against wind, water and wave erosion and damage; watershed protection for water supply; habitat for important species such pollinators; and temperature regulation are examples of ecosystem services. Adjusting forest management practices to enhance ecosystem services could include choice of species, adapting silvicultural practices, or adjusting management objectives (e.g. to give more weight to forest conservation or soil and water protection over production).

Estimates of up to 2 billion hectares of land worldwide have the potential to be restored. Forest and landscape restoration represents a tremendous opportunity to increase land's resilience, productivity and ability to deliver ecosystem services. These will, in turn, increase the resilience of people living in and around these landscapes. Land restoration efforts should take into account risk and vulnerabilities and seek to build ecosystem and human resilience. Measures might include use of species and varieties suited to the changing conditions and that could yield valuable products for local use or sale, diversification of species enhancing vegetative cover in areas of higher risk of erosion.

Forests are home to large numbers of indigenous peoples. In many areas, indigenous peoples are characterized by high levels of poverty, geographic isolation, and lack of economic and employment opportunities. Their vulnerability is exacerbated when they have insecure land and resource tenure. Special attention to securing their rights and strengthening their resilience is needed. Indigenous peoples and forest communities have a wealth of traditional knowledge about ways to reduce risk and to adapt to change and shocks of various sorts. This knowledge is an important resource to be tapped for adaptation efforts.

2.4 - Fisheries and aquaculture systems

In addition to the restoration and building up of the fisheries and aquaculture social-ecological systems' resilience through the implementation of the 1995 FAO Code of Conduct for Responsible Fisheries and the Ecosystem Approach to Fisheries and Aquaculture, the fisheries and aquaculture sector may also rely on risk spreading or reduction measures, such as livelihood diversification away from the sector, disease and disaster risk management, and creative combinations of public and private insurance tools to reduce vulnerability within the sector and dependent communities. Traditional fisheries and aquaculture policy, investment and management planning can be "climate proofed", such as by allowing spatial and temporal tools adapt to climatic variables, or by explicitly incorporating uncertainty and adaptability into current management and development plans. At the regional level, regional agreements among countries sharing transboundary stocks can also be adjusted as shifts in stock distributions and changes in productivity occur.

Technical innovation will also provide some adaptation options along the supply chain, such as the breeding of saline resistant aquaculture species to confront sea level rise, the development of storm resistant fish farming systems (e.g. sturdier fish cages), and the widespread use of information technology to share weather as well as market information. Fishing vessels of all sizes may be rendered more stable to allow for fishing further away from the coastal area to follow targeted species as they move to cooler waters and production and post-harvest processes can be assisted in their transition to new species, climatic conditions and in accessing and developing new markets. In addition, waste and spoilage reduction across the fish supply chain will greatly reduce food security vulnerabilities to climate change. An example of technical innovation

[28] Angelsen and Wunder, 2003.

can be found in case study 2 “small-scale fisheries in South Africa use a mobile-based information management systems”.

Proper aquaculture zoning mechanisms at the watershed level, biosecurity frameworks, risk analysis and strategic environmental assessments that take into account the added effects on aquaculture farms would enable the sector to better face potential threats such as new diseases, invasive species and eutrophication related problems that can be exacerbated by climate change (e.g. increased water temperature and salinity). Diversification within aquaculture, and especially exploring new opportunities in mariculture or in inland areas with increased precipitation, potentially offer new adaptation options.

The recent Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (the SSF Guidelines)[29] call on providing small-scale fisheries and aquaculture systems and communities with the enabling environments to ensure their resilience to extreme events and climate change, ensuring secure tenure and access rights to the natural resources upon which they depend.

2.5 - Building resilience at landscape level

The scope for adaptation is particularly evident through the landscape approach Many ecosystem services relevant for agricultural production such as pollination, pest and disease resistance, watershed protection and erosion control, are directly related to the resilience of agricultural livelihoods through their impacts on reducing environmental risks and improving coping capacities.[30]

Adopting a landscape approach to management includes taking into consideration the physical and biological features of an area as well as the institutions and people who influence it. The interconnectedness of these factors underlines the value of working across sectors and addresses environmental, social and economic issues in an integrated way. The landscape approach is a useful way in which to work in an integrated manner. It is conducive to building the resilience of land-use systems, natural resources and people’s livelihoods in a cohesive way and supported by effective institutional and governance mechanisms. It is more likely to optimize their contributions to the stability and vitality of ecosystems and their ability to support societal needs in a sustainable manner. Understanding the dynamics between the different elements (biophysical, social, economic and institutional) and engaging local stakeholders in decision-making will help in the development of strategies and actions to increase resilience.[31/32]

A good example of the landscape approach can be found in mountain ecosystems that are severely hit by and very sensitive to climate change. They are considered early indicators of climate change that can impact on drinking water supplies, hydropower generation, and agricultural suitability and an increase the occurrence of natural hazards.[33] Agroecology offers another pathway towards increasing resilience of landscapes. Agroecology can play a critical role to better understand and value ecosystem services provided by interactions inside a specific system. It also enables strengthening them in order to improve the efficiency and resilience of the system. Integrated management techniques based on ecosystem approaches (e.g. soil

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[30] FAO, 2007; McCarthy et al., 2010.

[31] Braatz, 2012.

[32] Two examples of integrated approaches within a wider landscape context are provided below (taken from FAO, 2012b): Watershed management has been successfully used to restore and maintain the agro-ecological viability and production potential of various watersheds throughout the world, using land-use management techniques that integrate across sectors and also address socio-economic concerns of local populations. Decades of strong technical support and lessons learned in the process have led to increased awareness by decision-makers of the importance of supporting integrated watershed management programmes and projects that engage local stakeholders in participatory planning and management (FAO, 2006).

[33] http://www.mountainpartnership.org/publications/publication-detail/en/c/357944/

conservation, reduced external input, biodiversity, nutrients cycling, farm diversification, livestock-crop integration, agro-forestry) have the potential of providing dynamic responses that can be adapted and adopted locally, according to the diversity of context and priorities, simultaneously combining adaptation and mitigation strategies, increasing overall resilience of systems and livelihoods. These techniques can be far more energy-efficient and release fewer direct and indirect GHGs to the environment while sequestering more GHGs than current intensive or industrial agriculture. Furthermore, these approaches put small holder food producers and livelihoods in the center, not only for the genetic diversity they actively maintain, but for their capacity to respond to changing circumstances through experimentation, adaptation and innovation. Given its participatory nature, agroecology provides a framework for collaborations between researchers and farmers that co-create knowledge and build upon innovation at local levels, strengthening climate change mitigation and adaptation simultaneously. This also ensures that learning processes stay rooted in local realities and their outcomes are readily applied.

At landscape level the resilience of livelihoods can be increased by devising appropriate social protection strategies that includes addressing gender-related vulnerabilities. Additionally, disaster risk reduction for food security and nutrition in the context of climate change adaptation enables people to adapt to changing conditions more easily now and in the future.

Key Area 3: MANAGING GENETIC RESOURCES [34]

Genetic resources for food and agriculture play a crucial role in food security, nutrition and livelihoods and in the provision of environmental services. They are key components of sustainability, resilience and adaptability in production systems. They underpin the ability of crops, livestock, aquatic organisms and trees to withstand a range of different climatic conditions. Crops, livestock, trees and aquatic organisms that can survive and produce in future climates will be crucial in future production systems.[35] For example, livestock breeds raised in harsh production environments over a long period of time tend to acquire characteristics that enable them to cope with these conditions. It is therefore essential to secure and mobilize genetic resources as part of national and global climate change adaptation planning. In parts of the world, new combinations of temperature, moisture availability and day length are creating production environments not experienced previously for which adapted materials may not exist. Please refer to case study 5 “community-based management of genetic resources in Honduras”.

Coping with climate change will require revising the goals of breeding programmes (HLPE, 2012a) and in some places the introduction of new varieties and breeds, even species. Improvements to *in-situ* and *ex-situ* conservation programmes for domesticated species, their wild relatives and other wild genetic resources important for food and agriculture, along with policies that promote their sustainable use, are therefore urgently required.

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[34] Genetic resources for food and agriculture encompass the diversity of plants, animals, forests, aquatic resources, micro-organisms and invertebrates that play a role in food and agricultural production. While these life forms are themselves threatened by climate change, their genetic makeup makes them key players in addressing the challenges such changes present. If properly conserved and used, for example, plant genetic resources may provide seeds that can tolerate or thrive amid greater aridity, frost, and flooding or soil salinity.

[35] FAO, 2015a, Galluzzi *et al.* 2011.

The FAO's *Voluntary Guidelines to Support the Integration of Genetic Diversity into National Climate Change Adaptation Planning*[36] aim to assist countries in managing genetic resources as a pivotal reservoir and tool at their disposal to adapt agriculture and build resilience into agricultural and food production systems. The Guidelines include a list of adaptation measures in the different sectors of crop, livestock, forestry, fisheries and aquaculture in the following areas:

i) Conservation
ii) Improve production system adaptability and resilience
iii) Improve specific adaptation of crops, domestic animals, forest tree and aquatic species
iv) Availability and accessibility
v) Supporting actions

Key Area 4: INVESTING IN RESILIENT AGRICULTURAL DEVELOPMENT

Agriculture, being the main livelihood source for more than 35 percent of the world's population, is crucial to reduce the growing impact of climate-related extreme events on the sectors by investing in disaster risk reduction and adaptation technologies and practices that enhance the resilience of agriculture and food production systems, reduce poverty and increase food security. Targeted investments are needed to increase the resilience of agro-ecosystems through sustainable land management approaches, together with programmes to enhance socio-economic resilience such as social protection, improved agricultural market governance and value chain development, as well as insurance programmes and effective early warning systems. Please refer to case study 6 "Piloting a new methodology for assessing irrigation investment needs in Egypt".

A basic set of questions depending on the agricultural sector could guide the analysis of resilience of proposed investments. In the fisheries sector, for example a question might be: are catches generally increasing, decreasing or stable? In addition to following a set of questions, the communities should test the viability of the investment against a set of conditions (flood, later onset of rain, sea level rise etc). This involves considering the viability of the commodity being produced (i.e. crop or livestock), as well as the means of production (e.g. cultivation practices, land husbandry, livestock husbandry, buildings, shelters). The key question to ask is whether the investment would continue to be viable/profitable/productive.

4.1 - Promoting agricultural development for economic growth, alleviation of poverty and reduction of vulnerabilities in rural areas, focusing on smallholder and small-scale systems

Combatting climate change goes hand in hand with alleviating poverty, which requires mainstreaming climate responses within pro-poor development strategies. Consequently, there is increasing support for mainstreaming climate change responses within human development and poverty alleviation rather than pursuing separate climate and poverty tracks and risking potentially negative outcomes for one or the other of these goals. This approach is exemplified by the climate-smart Agriculture (CSA) approach, which aims to identify and encourage policies that can achieve benefits for poverty alleviation, climate adaptation and potential greenhouse gas emission reduction. Mainstreaming involves the integration of information, policies and measures to address climate change in ongoing development planning and decision-making. Mainstreaming should create "no regrets" opportunities for achieving development that is resilient to current and future climate impacts for the most vulnerable groups, and avoid potential trade-offs between adaptation and development strategies, which can result in maladaptation.

4.2 - Enabling in-farm and off-farm diversification

Within the agriculture sectors, there are many opportunities for in-farm diversification, such as shifting to integrated rice-fish farming or increasing the number of crop and species varieties within any given system.

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[36] Available at http://www.fao.org/documents/card/en/c/290cd085-98f3-43df-99a9-250cec270867/

It is also important to recognize that an important strategy for increasing resilience among agricultural, fisheries and forestry-based populations is to diversify to non-agricultural sources of income and in many cases to exit from agriculture for employment opportunities in other sectors. In many micro-level studies of agricultural household welfare, the access to off-farm income sources from labour diversification is generally positively associated with welfare levels.[37] In this respect, diversification is emerging as an important option in terms of the adaptation component of a country's CSA strategy. For example, labour migration is a common strategy in the face of climate risk and environmental degradation, and remuneration from these migrants plays an important role in maintaining household resilience. Please refer to case study 7 "The traditional Minga system for drought management in Bolivia" and case study 8 "Cassava to be included in the adaptation strategy for African crop production". For most farming families, agriculture is only one of several sources of income and smaller size households often have higher shares of non-agricultural incomes than larger ones.

Key Area 5: INVESTING IN SYSTEMS TO ASSESS RISKS AND VULNERABILITIES

Assessments can help determine how local climate conditions and their impact on agriculture, the natural resource base, food security and livelihoods have been changing and are projected to change in the future. They can also identify the most vulnerable locations and contexts that require adaptation actions. Knowing which agricultural systems and livelihood activities may be more sensitive to a changing climate, for example, will help practitioners choose more resilient crops, livestock, aquatic and forestry species and adopt more diversified livelihoods. Informing stakeholders of the changing amounts of rainfall and the spatial distribution of precipitation will help them to better allocate resources for the management of water resources. In addition, given the multiple environmental changes driven by climate change, it will be necessary to develop environmental monitoring systems, focusing on key parameters. An example can be seen in case study 9 "Introducing good practice technology options for DRRM in the Philippines".

5.1 - Monitoring the impact of disasters on crops, livestock, fisheries, aquaculture and forestry

Over the past decade, the number of climate-related disasters has increased sharply together with the resulting economic losses. FAO estimates that between 2003 and 2013, the agriculture sectors absorbed approximately 22 percent of the damage and losses caused by disasters in developing countries[38]. Sector-specific quantitative data on disaster losses are necessary to understand the breadth and scope of disaster impact on agriculture and livelihoods so as to design adequate responses. Better information on damage and losses from disasters can also be used to assess the benefits of increased investment in prevention, adaptation to and mitigation of risks.

5.2 - Evaluating costs and benefits of risk reduction and adaptation options

Measuring costs and benefits of risk reduction and adaptation options facilitates evidence-based decision-making and planning to effectively address risks and vulnerabilities. The goal is to measure the extent of avoided damage and losses from extreme climate events in agriculture in order to guide the selection of good practice technologies likely to maximize the returns and enhance the resilience of farmers, herders, fisher folks, and forest- and tree-dependent people. Integrated assessments of adaptation and risk reduction options include an estimation of costs, added benefits, avoided costs, and co-benefits from an economic, social and environmental perspective. Potential trade-offs specific to women also need to be analysed as often without more targeted support and services that address women's needs, the challenge of achieving adaptation benefits will remain significant.[39] Ideally, options are assessed against several criteria including (i) agro-ecological suitability; (ii) socio-economic feasibility; (iii) hazard resilience; and (iv) climate change

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[37] Asfaw *et al*. 2015.
[38] FAO, 2015. The Impact of Disasters on Agriculture and Food Security.
[39] Gender in Climate-Smart Agriculture. Module 18 for the Gender in Agriculture Sourcebook, 2015.

mitigation co-benefits. For other examples please refer to case study 10 “Participatory local fishery and aquaculture monitoring systems on the Mekong River” and case study 12 “Vulnerability analysis to potential solutions with a CSA approach in Zambia”.

Key Area 6: ENABLING ADAPTATION THROUGH POLICIES AND INSTITUTIONS

The economic and technical options presented above need to be enabled, supported and complemented by appropriate policies and institutions where bridges are built to integrate climate change concerns in food and agricultural policies, coupled with better recognition of the specificities of the agriculture sectors and of their key role for food security and nutrition in climate policies. Please refer to case study 13 “Plan of action for Disaster Risk Management in the Lao People’s Democratic Republic”, as an example of how adaptation is enabled through policies and institutions. Several types of policies and institutions can be distinguished to enable the adaptation of food producers to climate change, at national and international levels:
Policies and institutions to support food producers and supply chains, especially small-scale food producers, in their efforts to adapt.

- Policies and institutions that facilitate and support collective elaboration and implementation of adaptation actions either at the landscape level (for instance a watershed, a forest) or at the sector level.
- Policies and institutions dedicated to the prevention and management of specific risks and vulnerabilities that can be modified by climate change, such as plant pests, animal diseases, invasive species, wild fires, etc.

6.1 - Building institutions and policies to support the transition to more resilient systems

To adopt new and more resilient livelihoods, farmers, herders, fishers and foresters and other actors along the supply chains need to be operating in an institutional environment that supports such change. See case study 14 “Adaptive regional fisheries management in the Western Pacific Ocean” for an example of this.

In addition, climate change gives rise to new and increased demands for collective action. This requires appropriate policies and institutions that facilitate and support collective elaboration and implementation of adaptation actions either in a space (for instance a watershed, a forest) or sector, for instance along the food chain, including to increase and adapt storage facilities. This can be done by improving inclusiveness and transparency of decision-making and providing means to incentivize actions that provide public and collective adaptation benefits in the long term. Cross-sectoral coordination will need to be fostered by policies to enable a systems-wide approach to adaptation. In this effort, institutions at all levels need to address the priorities of men and women, endowments and constraints. Consultation processes must include women’s voices to achieve more gender-responsive agricultural- and climate-related interventions. This is also crucial in making climate-financing instruments and public investments more responsive to the differentiated needs of men and women in decision-making about adaptation measures.

National governments could provide mechanisms for proactive and integrated risk management with institutions for risk monitoring, prevention, control and response at the local and global levels, and incentives for private sector participation in risk coping. Social protection programmes that guarantee minimum incomes or access to food also have potential through their effects on production choices and prices.

Climate change concerns will need to be integrated in all agriculture sectors and food security strategies and policies and will require coordination with those related to water management, land and natural resource management, rural development and social protection, among others. And the needs of agriculture sectors as well as food security and nutrition need to be integrated into climate change strategies and policies. Facilitating the consideration and integration of food security and agriculture concerns and perspectives into national and global adaptation processes requires an ability to communicate vulnerabilities and adaptation priorities to non-agriculture specialists as well as an ability of agriculture stakeholders to better identify and

understand the issues at stake in a mid/long term perspective and to empower them to participate efficiently in these processes. Also see case study 11 “Multi-disciplinary assessment system for risks and vulnerabilities in the agriculture sectors for medium to long-term adaptation planning”.

6.2 - Strengthen research in resilience in agriculture including indigenous peoples’ knowledge

Under changing climates, challenges to agriculture are diverse and unpredictable. Research must adapt to these new challenges. Climate change underlines the importance of context-specific and continuously adapted knowledge to find solutions for complex and dynamic ecological and human systems. This requires greater decentralization of research systems in order to find locally adapted solutions in a range of different agro-ecosystems. It also requires the greater participation of the end-users of agricultural research: farmers and indigenous peoples who have an important knowledge of local natural resources, as well as social, economic and political contexts that shape technology choices. By combining their knowledge with scientific understanding, complex adaptive farming systems can be designed that effectively address food security and nutrition.

The research findings and innovations that farmers and indigenous peoples may use or develop in one place can be of great interest to those in other locations with similar ecologies or challenges. Platforms to bring farmers together – and to encourage exchange of knowledge between farmers and scientists – will play an increasingly important role and can include farmer exchange visits, seed networks, farmer field schools, field days, and more. Policies could support the participation of farmers and indigenous peoples in all phases of the research process (from setting research priorities to developing new technologies). They could also ensure that farmers and indigenous peoples continue to have access to the natural resources that are needed to sustain their production and innovation systems.

Moreover, indigenous peoples have a critical role in climate risk management. For example several mountain specific adaptation measures have been based on sustainable indigenous and traditional knowledge and practices for regulating water cycles, reducing soil erosion, applying sustainable agricultural techniques, diversifying sources of income and increasing the resilience to hazards and shocks.[40] Indigenous knowledge has to better documented and widely shared so that communities and countries can learn from each other.

6.3 - Enhance markets and trade’s contribution to stability of food security

Global markets and trade can play a stabilizing role for prices and supplies and provide alternative food options for negatively affected regions by changing conditions or by finding regions where food can be produced more efficiently. Nonetheless, trade alone is not a sufficient adaptation strategy, owing to several trade-offs. Dependence on imports to meet food needs may increase the risk of exposure to higher market and price volatility that is expected under climate change. Furthermore, climate change fundamentally alters global food production patterns and, given the fact that impacts are expected to be worse in low-latitude regions, climate change is likely to exacerbate existing imbalances between developed and developing countries. Spatial differences are also observed at regional and sub regional scales, particularly where there are substantial differences in elevation. The impacts of climate change (and of climate mitigation policies) thus have a major impact on patterns of global trade[41]. In addition to the direct impact of climate change on primary production, changing socio-economics can alter comparative advantages and trade flows, and potentially alter future international competitiveness and agri-food trade patterns.[42]

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[40] Kohler, T., Wehrli, A. & Jurek, M., eds. 2014. Mountains and climate change: A global concern. Sustainable Mountain Development Series. Bern, Switzerland, Centre for Development and Environment (CDE), Swiss Agency for Development and Cooperation (SDC) and Geographica Bernensia.
[41] Elbehri, Elliott and Wheeler, 2015
[42] Ahammad *et al.* 2015.

6.4 - Strengthen regional and international cooperation

As a result of climate change, agricultural production will continue to shift both within and between countries. This calls for strengthened regional and international cooperation to facilitate exchanges of knowledge, manage shared fish stocks and water resources, and transhumance, and exchange and valorize genetic material and practices. International instruments like the International Plant Protection Convention (IPPC) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) can play a major role in supporting adaptation efforts.

Annex 2 - Examples of adaptation options in agriculture sectors[43]

Table 1: Options for adaptation to climate change at farm level (crop systems)

Risk	Response
Changing climate conditions and climate variability and seasonality	Participate in monitoring schemes when available. Optimization of planting schedules such as sowing dates (including for feedstocks and forage). Plant different varieties, species or cultivars of crops. Use of short duration cultivars. Varieties or breeds with different environmental optima may be required, or those with broader environmental tolerances. The use of currently neglected or rare crops and breeds should be considered. Early sowing enabled by improvements in sowing machinery or dry sowing techniques. Increased diversification of varieties or crops to hedge against risk of individual crop failure. Use intercropping. Make use of integrated systems involving livestock and/or aquaculture to improve resilience. Change post-harvest practices, for example the extent to which grain may require drying and how products are stored after harvest. Consider the effect of new weather patterns on the health and well-being of agricultural workers.
Change in rainfall and water availability	Participate in monitoring schemes when available. Change irrigation practices. Adopt enhanced water conservation measures. Use marginal and waste water resources. Make more use of rainwater harvesting and capture. In some areas, increased precipitation may allow irrigated or rain-fed agriculture in places where previously it was not possible. Alter agronomic practices. Reduced tillage to lessen water loss, similarly the incorporation of manures and compost, and other land use techniques such as cover cropping increase soil organic matter and hence improve water retention.
Increased frequencies of droughts, storms, floods, wildfire events, sea level rise	Participate in monitoring schemes with available General water conservation measures are particularly valuable at times of drought. Use flood, drought and/or saline resistant varieties. Improved drainage, improved soil organic matter content and farm design to avoid soil loss and gullying. Consider (where possible) increasing insurance cover against extreme events.
Pest, weed and diseases, disruption of pollinator ecosystem services	Participate in risk monitoring and preventing schemes when available. Use expertise in coping with existing pests and diseases. Build on natural regulation and strengthen ecosystem services.

[43] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf.

Table 2: Climate change adaptation options in the livestock sector

Animals	Forage and feed crops	Labour force and capital
• Water management (e.g. boreholes) • Breed on resistance to drought, heat and harsh environments • Shifts in species, breeds and/ or production system (e.g. small ruminants, poultry) • Disease control and animal health • Cooling (indoor systems) or provide shade (e.g. trees)	• Irrigation • Purchase feed, supplementation • Breed feed crops and forages for water use efficiency and for resistance to drought, salinity and waterlogging • Grazing management • Changes in cropping calendar • Agroforestry • Increase mobility for resources	• On- and off-farm diversification • Insurances • Reconversion (in the context of national/regional production zoning) • Institutional changes (e.g. trade, conflict resolution, income stabilization programmes

Table 3: Examples of measures to increase forest resilience to various impacts of climate change

Risks/impacts	Implications (social, economic, environmental)	Response measures for risk reduction and increased resilience
Decreased forest vitality and productivity	Reduced revenue from wood and non-wood forest products; reduced forest ecosystem services	Adjust silvicultural practices, change composition of species and varieties; increase forest biodiversity; implement forest restoration measures
Increased forest pests and diseases	Reduced forest revenue; reduced forest ecosystem services	Implement and intensify pest and disease management measures; adjust silvicultural practices
Increased wildfires	Loss of life; damage to infrastructure; reduced forest revenue and ecosystem services; wildlife losses	Implement and intensify wildfire management; adjust silvicultural practices
Increased water erosion and landslides	Damage to forest and to infrastructure (towns, roads, dams); reduced water quality	Undertake watershed management measures (including protecting and increasing vegetation cover; reducing intensities of harvesting and other uses)
Drought-induced forest/tree dieback and land degradation	Reduced availability of forest products; increased wind damage; reduced grazing values	Plant windbreaks; maintain tree cover; change composition of species and varieties
Increased storm damage	Reduced forest revenue and ecosystem services; increased risk of pests and disease	Change species and adjust tree spacing to reduce risk; salvage harvesting; pest/ disease control
Reduced extent and vitality of mangroves and coastal forests	Increased exposure of land to storm damage; reduced productivity of coastal fisheries	Increase protection, restoration and enhancement of mangroves and other coastal forests
Changes in species ranges and species extinctions	Reduced forest ecosystem functions; loss of forest biodiversity	Restore/increase forest connectivity and wildlife corridors; assist migration; take *ex-situ* conservation actions

Table 4: Overview of practical options for reducing vulnerability in fisheries and aquaculture

Impact area	Potential responses
Capture fisheries	
Reduced yield	Access higher-value markets; shift/widen targeted species; increase fishing capacity/effort*; reduce costs/increase efficiency; diversify livelihoods, exit fishery
Increased yield variability	Diversify livelihoods; implement insurance schemes; promote adaptive management frameworks
Change in distribution	Migrate fishing effort/strategies and processing/distribution facilities; implement flexible allocation and access schemes
Sea-level change, flooding, and surges	New/improved physical defences; managed retreat/accommodation; rehabilitation and disaster response; integrated coastal management; early warning systems and education
Increased dangers of fishing	Weather warning systems; improved vessel stability/safety/communications
Social disruptions/new fisher influx	Support existing/develop new local management institutions; diversify livelihoods
Aquaculture	
Extreme weather events	Improve farm siting and design; individual/cluster insurance; use indigenous or non-reproducing stocks to minimize biodiversity impacts
Temperature rise	Better water management, feeds, handling; selective breeding/genetic improvements; adjust harvest and market schedules
Water stress and drought conditions	Improve efficacy of water usage; shift to coastal aquaculture, culture-based fisheries; select for short-cycle production; improve water sharing; improve seed quality, efficiency,
Sea-level rise and other circulation changes	Shift sensitive species upstream; introduce marine or euryhaline species (wide salinity tolerance); use hatchery seed, protect broodstock and nursery habitats
Eutrophication/upwelling, harmful algal blooms	Better planning; farm siting; regular monitoring; emergency procedures
Increased virulence of pathogens, new diseases	Better management to reduce stress; biosecurity measures; monitoring; appropriate farm siting; improved treatments and management strategies; genetic improvement for higher resistance.
Acidification impact on shell formation	Adapt production and handling techniques; move production zones, species selection
Limits on fish and other meal and oil supplies/price	Fish meal/oil replacement; better feed management; genetic improvement for alternative feeds; shift away from carnivorous species; culture of bivalves and seaweeds
Post-harvest, value addition	
Extreme event effects on infrastructure/ communities	Early warning systems and education; new or improved physical defences; accommodation to change; rehabilitation and disaster response
Reduced/more variable yields, supply timing	Wider sourcing of products, change species, add value, reduce losses, costs; more flexible location strategies to access materials; improve communications and distribution systems; diversify livelihoods
Temperature, precipitation, other effects on processing	Better forecasting, information; change or improve processes and technologies
Trade and market shocks	Better information services; diversify markets and products

Source: adapted from Daw *et al.* (2009); De Silva and Soto (2009)
*Note: Some autonomous adaptations to declining and variable yields may directly risk exacerbating overexploitation of fisheries by increasing fishing pressure or impacting habitats.

Annex 3 - Potential gender considerations of various climate-smart agriculture practices

Table 5: Potential gender considerations of various CSA practices

CSA options/ practices	Contribution to CSA goals relating to:			Gender impact	Requirements for adoption of practice					
	Climate change adaptation	Mitigation (reducing GHGs)	Potential household food security and nutritional impacts	Women's control of income from practice	Relative amount of time until benefits are realized	Potential for women to benefit from increased productivity	Female and youth labour availability	Female access to and control of land	Female access to water for agriculture	Female access to cash and ability to spend it
Stress-tolerant varieties	High	Low	High	Low	Low	Mediu m	Medium	High	Low	High
High-yielding varieties	Low	Low	High	Low	Low	High	Medium	High	High	High
Conservation agriculture	High	Medium	High	Low	High	High	Low–Medium	High	Low	Low
Improved home gardens	High	Medium	High	High	Low	High	High	High	High	High
On-farm tree planting	High	High	Low–Medium	Low	High	Mediu m	High initially; Low later	High	High	Medium
Composting	Medium	Medium	Medium	Medium	Low	Mediu m	High	Med ium	Low	Low
Small-scale irrigation	High	Low	High	Low–Medium	Low	High	Medium	High	High	Medium
Fodder shrubs	High	Medium –High	High	High	Medium	Mediu m	High	High	Medium	Low–Medium
Herbaceous legumes	High	Medium	High	High	Medium	High	High	High	Medium	Low–Medium
Improved grasses (e.g., Napier)	High	Medium	High	High	Low	High	High	High	Medium	Low
Livestock genetic improvement	High	Medium	Medium –High	Low–High	High	High	Low–High	Low	High	Medium
Restoration of degraded rangeland	High	High	Medium	Low	High	High	Low–High	High	Low	Low

Source: Gender in Climate-Smart Agriculture. Module 18 for the Gender in Agriculture Sourcebook (FAO, World Bank, IFAD, 2015).

Annex 4 - Case studies

This Annex contains short cases illustrating the **six key areas of adaptation measures** implemented in the agriculture sectors and for food security referenced in the main text**.** They reflect different vulnerabilities and risks, scales, methodologies, and principles from ongoing FAO projects in different subsectors and at the different levels of intervention requested (regional, national and local). Though referenced in specific sections they are usually cross-cutting, reflecting more than one of the key areas of adaptation measures.

Case study 1: Farmer field schools to integrate climate resilience in Mali[44]

Launched in 2012, the Mali project "Integrating climate resilience into agricultural production for food security in rural areas" builds on some 15 years of field expertise of the Integrated Pest Management Programme (IPPM) on farmer field schools (FFS) and sustainable agriculture supported by FAO and implemented by governments and national stakeholders.

The FFS approach is a community-education approach based on the principles of experimentation, learning by doing and cooperation. Through weekly field learning sessions, groups of 20–25 farmers from the same village are provided with a risk-free environment to test innovations and build their capacity to adapt to climate change throughout the season. Learning is facilitated by a facilitator who underwent the same learning cycle over a season to understand the principles of non-formal education while learning about existing climate change adaptation practices. Therefore, FFS provide ideal learning platforms for farmers to adapt existing climate change adaptation practices from research, extension and traditional practices to their own needs and contexts, as necessary for effective locally-adapted climate change adaptation to take place.[45]

The project in Mali aimed to strengthen farmers' capacities to adapt to climate change, building upon an expanding network of FFS initiatives already supported by FAO and the Malian Government. Thanks to the full involvement of the national and local authorities, the project was able to scale up the FFS/climate change adaptation approach from 9 communes (2012) to more than 134 communes (2014). It resulted in the capacity building of 16 237 producers of which 5 321 women, the adoption of improved seeds in 242 villages within 134 communes, with the dissemination of 13 improved/adapted varieties of sorghum, cowpea, rice, millet and maize in three agro-ecological zones; the implementation of four new agroforestry perimeters managed and maintained by four farmers organizations, of which 75 percent of the members are women. It also included the preparation of a facilitators' training guide embedding more than 30 modules on FFS/climate change adaptation best practices.

Case study 2: Small-scale fisheries in South Africa use a mobile-based information management system[46]

With the increasing affordability of mobile devices and rapid rural coverage expansion and new mobile apps, more and more organizations are making use of this form of communication to develop real-time monitoring systems to address some of the world's more pressing social and ecological challenges. An example of a multiple-use mobile phone application is allowing fisheries communities in South Africa to be integrated into participatory information and resource networks, exchanging information ranging from fishery and environmental monitoring and maritime safety to fisheries management, local development and market opportunities. With this knowledge, fishers engage with the fisheries authority to support co-management of the fisheries resources, receive important weather and market information and, at the same time, record a range of atmospheric (wind direction, strength, cloud cover, etc.) and oceanic (surface temperature, current strength and direction, water colour and clarity, etc.) information. Complemented with other climate

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[44] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf
[45] FAO, 2013c, Winarto *et al.*, 2008.
[46] http://abalobi.info/

data and scientific knowledge, these data enable fishers and managers to track environmental and species changes and plan for adaptation measures in a participatory and highly contextualised manner. This system, being developed and tested in South Africa will improve the resilience and livelihoods of the more than one hundred thousand households involved in the small-scale fisheries sector along the South African coast.

Case study 3: Increasing rural women's income through climate-smart agriculture in Western Kenya[47]

Climate change in northwestern Kenya—a major source of food crops and livestock products for the country as a whole—may provoke major changes in the productivity of key agricultural enterprises, with far-reaching implications for national food and nutrition security and farmers' livelihoods. A pilot project under FAO's Mitigation of Climate Change in Agriculture (MICCA) program, initiated in Kenya in September 2011, focused on small-scale female and male dairy farmers, with the aim of integrating climate-smart agriculture (CSA) into the farming system and improving farm and milk productivity, income, and livelihoods.

In the Kamotony area, women concerned about providing for their children in hard economic times formed a group but could not determine what they could do to improve their prospects. Through the pilot project, they received training in CSA practices and decided to establish a tree nursery. Sales of indigenous tree seedlings, tea cuttings for planting material, ornamental trees, and garden flowers gave them a financial stepping-stone for investing in dairy production. They increased their farms' milk productivity after applying the knowledge gained through training in improved fodder production, feed storage, and dairy cattle management. The new practices allowed them to reduce risks and access credit, which enabled them to make further investments in their agricultural enterprises.

The women report that now they can pay their children's school fees without difficulty. Some use the proceeds from milk sales to make monthly contributions to the National Health Insurance Fund for their family members. They have improved household nutrition by applying compost and manure to home gardens and growing passionfruit. The members of this group were among the 90 percent of the female-headed households in the project area who perceived that the adoption of climate-smart agriculture practices had increased their incomes and household food and nutrition security.

They also suggest that the adoption of CSA practices has generally reduced levels of stress and enhanced cohesion in their homes. The success has made it easier for the women groups' to adopt some practices such as agroforestry, which ordinarily would be difficult for cultural and gender reasons. The trees they planted provide herbs and fuelwood; time that is no longer spent collecting wood is used productively in other activities. Looking forward, this women's group will use income from milk sales not only to build social capital as a dairy management group but also to increase their financial capital through regular savings.

Case study 4: Livestock as a tool for adaptation in the drylands[48]

In the dry lands of Sub-Saharan Africa, FAO has collaborated with the World Bank, CIRAD, IFPRI and *Action contre la Faim* to assess livestock production under climatic constraint and propose interventions to increase productivity and reduce the impact of climate variability on livestock outputs. Volume and quality of feed supplies were assessed as well as the degree to which they could meet the animal requirements under different climatic and intervention scenarios, for the period 2012-2030.

Results show that 2.5 times more feed resource are needed in a baseline 2012-2030 scenario with similar climate then in the past (1998-2011), and 3.5 times more feed are needed in case of draught. They also show that there is a potential for livestock's growth if feed resources are made accessible, which calls for

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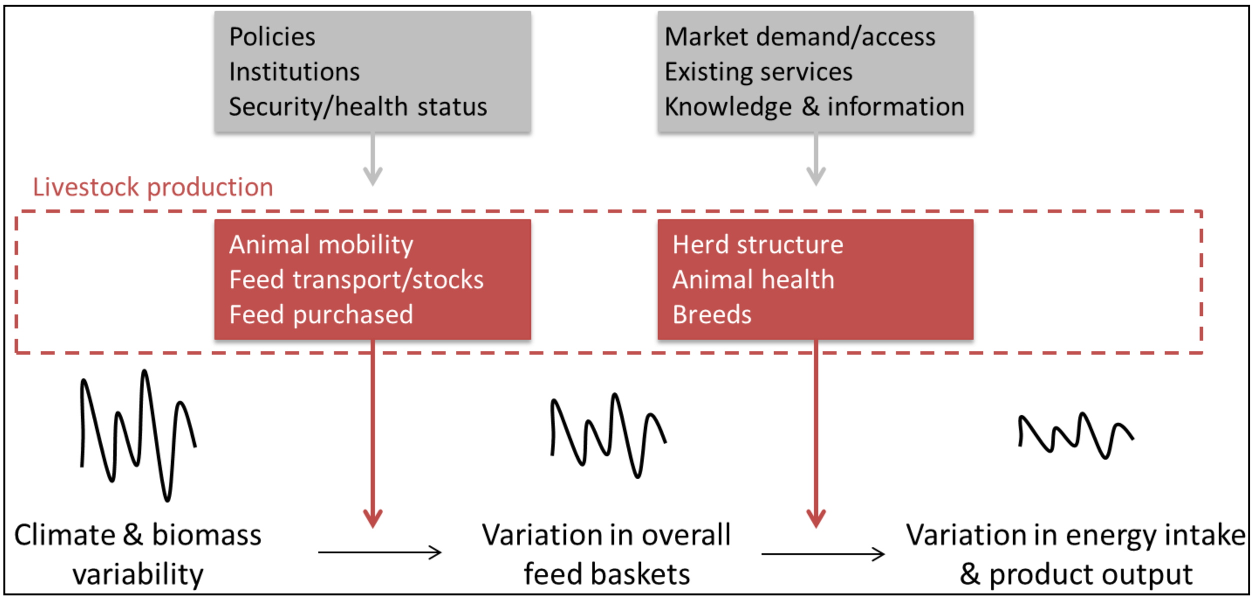
[47] Source: Mutoko, Rioux, and Kirui 2015 in Module 18 for the Gender in Agriculture Sourcebook. World Bank, FAO, IFAD. (2015) http://www.fao.org/3/a-az917e.pdf

[48] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

interventions in animal mobility (corridors, security, border regulations, health, tenure), feed management (storage, processing, transport) and stratification of production to reduce grazing pressure in arid areas. Interventions can significantly increase the output of livestock products in the African drylands (5 to 20 percent) if accessibility to feed is improved. Shocks brought 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: while inter-annual variability in biomass reaches 16 percent in the baseline scenario, variability in animal intake is brought down to 7 to 14 percent, depending on the interventions considered, and variability in animal product is brought down to 1 to 8 percent. Results therefore confirm that livestock is a strong asset for adaptation in pastoral areas.

Assessing the resilience of livestock production systems, their potential for future growth, and the combined need for long term investments and timely policy interventions is essential to informing the planning of policy makers, as well as the international community – to better enable them to carry out efficient and coordinated actions for climate change adaptation.

Figure 1: Attenuation of climate variability effect on herd performances (Mottet *et al*. 2015)[49]



[49] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

Case study 5: Community-based management of genetic resources in Honduras[50]

The need to replenish diversity in agricultural systems has encouraged the community management of genetic resources. This has resulted in the establishment of community seed banks to facilitate the revival and distribution of traditional and stress-tolerant crops and varieties.

In Honduras, farmers organized community-based agricultural research teams to diversify their plant genetic resources and develop hardier plant varieties that grow well on their soils. Responding to the higher occurrence of hurricanes, farmers were able to produce, through a participatory breeding process, improved maize varieties that are shorter and capable of withstanding the physical trauma brought by the hurricanes, with a higher yield and yet still adapted to high-altitude conditions. The selection process was accompanied by a conservation effort, as the seeds of the selected species are stored in a community seed bank, assuring availability of healthy and resistant plants.[51]

In Colombia, Panama, Peru, Bolivia, Ecuador, Thailand, India and other countries, indigenous organizations are actively involved in the protection of traditional knowledge and reintroduction of indigenous crop varieties of vegetables, tubers, grains, beans and fruit. The Potato Park in Cusco, Peru, was created in 2005 to protect the genetic diversity of local potato varieties and associated indigenous knowledge. The project demonstrates the link between the protection of agrobiodiversity and the protection of indigenous people's rights, livelihoods and culture. Indigenous Quechua communities involved in the project have brought back from a gene bank into their fields over 400 potato varieties to ensure the adaptation to changing climatic conditions.[52]

Case study 6: Piloting a new methodology for assessing irrigation investment needs in Egypt[53]

FAO has significant expertise in analysing and improving irrigation systems, and has developed a number of analytical tools and approaches to help identify and prioritize improvements to irrigation systems. The Mapping System and Services for Canal Operation Techniques (MASSCOTE) tool mainly consists of a detailed and comprehensive methodology for analyzing canal operation modernization. From diagnosis through to the formulation of operational units and the planning of a service, the MASSCOTE methodology allows tailored technical recommendations for optimizing the performance of irrigation canal systems to be developed. However, MASSCOTE does not currently cover in detail the assessment of investment needs, the ownership structure of irrigation systems i.e. which parts of the irrigation system are owned/ managed by which entities (e.g. central government, municipalities, irrigation companies, water user associations, etc.), the ability of the entities involved to borrow, nor their creditworthiness. Given the need to scale up investment in irrigation improvements, in 2013 the EBRD and FAO started joining efforts to developing the MASSCOTE tool further so that it can be used to inform investment activities in the irrigation sector, and identify irrigation investment priorities. EBRD and FAO are working to develop an additional 'financial/investment analysis module' that can help to identify and prioritize the specific investment needs of irrigation systems and opportunities for private sector participation in such investments. This would serve to identify and quantify the investment needs of specific irrigation systems and provide an investment framework for irrigation upgrades. This new module will be piloted in Egypt in the next few months.

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[50] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf
[51] USC Canada, 2008
[52] Argumedo, 2008
[53] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

Case study 7: The traditional Minga system for drought management in Bolivia[54]

Twenty-eight years ago, farmers from the Chiquitania region of Santa Cruz, Bolivia established a community adaption plan for climate change. As part of the plan, they developed a practice for harvesting rainwater to cope with the greater fluctuations in rainfall, as well as the increased concentration and high variability of rains. Using a diversified production system, they grow maize, cassava, peanuts and organic coffee.

The practice consists of digging a row close to the plants, filling it with manure and then covering it with mulch or vegetation residues. According to the farmers, this technique has increased their yields and kept production stable even during droughts. The manure improves the soil structure, thereby increasing water storage. It also increases the soil's nutrient content. Currently, this technique is being spread by the *Instituto Nacional de Innovación Agropecuaria y Forestal* and FAO to other communities to help them cope with water scarcity resulting from climate change.

Case study 8: Cassava to be included in the adaptation strategy for African crop production[55]

Farmers could adapt to climate change by growing short-term crops such as early maturing cassava, sweet potato, sorghum and millet, which are better suited to variable rainfall and shorter rainy seasons. The yields from these crops are far greater than from maize and beans. Cassava is potentially highly resilient to future climatic changes and could provide Africa with options for adaptation whilst other major food staples face challenges.

Cassava (Manihot esculenta Crantz), though native to South America, is one of the most important food staples in Sub-Saharan Africa (SSA), where it was introduced in the sixteenth century. Cultivated mostly for its starch storage roots in the tropical and subtropical regions of the world, Africa accounts for about 50 percent of the crop's annual global production. Its ability to produce relatively more than other crops in marginal environments makes it a strategic crop for food security in Africa. With proper husbandry, cultivating cassava offers immense potential for enhanced income and improved livelihoods for the mostly small-scale farmers. However, for cassava's full potential to be realized, many constraints must be overcome, these include yield and increased threats from pests and diseases. Studies (e.g. Jarvis *et al*. 2012) indicate that climate change could have a positive impact on cassava in many areas of Africa. We found that other major food staples are all projected to experience negative impacts, with the greatest impacts being on beans, potatoes, bananas, and sorghum. Cassava breeding could help in climate change adaptation, but despite an expected increase in mean temperature in South Africa, the current colder climate is a constraint.

Case study 9: Introducing good practice technology options for DRRM in the Philippines[56]

The Department for Agriculture (DA), Bicol Region, established a Technical Unit for DRRM in 2010 with technical advice from FAO. This unit coordinated, with support from FAO and the Central Bicol State University of Agriculture (CBSUA), the development of a Regional Plan of Action in agriculture and 15 community development plans for DRRM formally endorsed by municipalities and barangays in line with the implementation of DRRM Government Act 10121. A partnership agreement between the DA and the meteorological agency (PAGASA) led to the regular issuing of agro-climate information bulletins that inform farmers' crop choices before the agricultural seasons start and provide weather-related management advice on a monthly basis throughout the season. The pilot-testing of through farmer field schools raised awareness for the adoption of prevention and mitigation measures – such as the use of newly released submerged and

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[54] http://www.fao.org/3/i3325e.pdf
[55] http://www.fao.org/docrep/018/i3403e/i3403e.pdf
Jarvis *et al*. 2012 http://link.springer.com/article/10.1007%2Fs12042-012-9096-7
[56] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

saline-tolerant rice varieties – in recurrently hazard-prone communities. The development of a Web-based software application made it possible to monitor – based on seasonally updated field data and existing plot sizes – the performance of four main commodities (rice, maize, abaca and coconut). It reports on status and value of standing crops at any time during the cropping cycle. The standardized methodology enhances preciseness and speeds up the collection of loss and damage data in agriculture, and thus better informs relief and rehabilitation planning.

Case study 10: Participatory local fishery and aquaculture monitoring systems on the Mekong River[57]

Increased climate variability as well as the long term climatic shift both have a strong impact on aquatic environments and species. The tropical Mekong river area's mean daily discharge naturally varies enormously depending on the season, dry and flood. Climatic changes have already had an impact on the rivers' flood pulse affecting production, catches and livelihoods. In order to plan and protect the aquatic crops, fishers, fish farmers, planners as well as policy-makers would need to know in advance what kind of conditions and sudden events they can expect in the short and longer term.

With national partners, FAO is helping fishermen and fish farmers to adapt to the ongoing changes by setting up local monitoring systems in a participatory way. During the preparation of the monitoring system, it is important to identify main threats and forcing factors, such as salinity rise or increasing storminess, and their impact, such as an increase in aquaculture diseases or changes in species diversity, distribution and abundance. Secondly, it is important to define what should be monitored (e.g. main threats and vulnerability elements, water quality and fish condition, and select proxies for these): where the monitoring should focus, when it should be carried out, how often and by whom. In most cases resources limit the possibility and frequency to monitor anything other than hot spots. The aim is to involve local fishing and fish farmer community leaders, traders and specialized technicians, and to train them in monitoring. The collected data should be analysed by a multidisciplinary technical team who will also provide timely feedback to the local communities and connect the information to an early warning or disaster risk management system. The time aspects need to be considered so that the responses are reasonable in the short- and long term. Monitoring results should feed into decision- and policy-making processes as well as spatial planning of activities.

Case study 11: Multi-disciplinary assessment system for risks and vulnerabilities in the agriculture sectors for medium- to long-term adaptation planning[58]

While addressing short-term vulnerabilities to climate variability and extreme weather events in the agriculture sectors is imperative, a strengthened evidence-base on medium- to long-term climate change impacts on agriculture and vulnerabilities of farming systems/communities could guide governments in strategic investment planning, policies and programmes for adaptation.

As part of the AMICAF[59] project and an EU/FAO Programme, FAO supported the Philippines, Peru, and Morocco to assess potential impacts of climate change on their country's crop productivity and water resources under various climate change scenarios. A capacity development tool called MOSAICC[60] facilitated a collaborative working environment among country experts from different disciplines to work together to produce information on policy-relevant climate impact with sub-national disaggregation. In the Philippines and Peru, biophysical information on crops and water were further translated with econometric analysis to characterize vulnerable groups of people and to explore policy options to address the challenges.

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[57] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf
[58] http://www.fao.org/climatechange/mosaicc/87285/en/
[59] http://www.fao.org/climatechange/amicaf/
[60] http://www.fao.org/climatechange/mosaicc/

Case study 12: Vulnerability analysis to potential solutions with a CSA approach in Zambia[61]

FAO is working in Malawi and Zambia to build the climate-smart agriculture evidence and channel it into major policy processes at country and regional level. The project addresses in particular crop-livestock systems. A first component is carrying out an analysis and validation of climate variability through modelling the impacts of climate change on agriculture using the MOSAICC system, relying on existing information at national level and training to build capacity of country experts to conduct analysis of climate variability and extreme weather events.

A second component is screening the availability and suitability of leguminous cover crops and forages to the Zambian and Malawian farming systems for making cropping systems more resilient to climatic shocks such as dry spells, through improved soil cover (shadow, weed suppression, moderate soil temperatures, less water evaporation) and at the same time for the leguminous crops to fix nitrogen (N) in a natural way. Possible best bets for both cover and forage are to be identified to take advantage of the crop-livestock synergies.

A third component is conducting an assessment of livestock production under climate constraints looking i) at the inter-annual variability in biomass availability for livestock feed and its impact on animal production and ii) an assessment of the potential for improving productivity and reducing emissions Options were reviewed with representatives of the livestock sector in Zambia during a workshop. The Global Livestock Environmental Assessment Model was presented to the participants and specific parameters were collected. Options were implemented in the model and results revealed that feasible interventions in feed management, animal health and husbandry in Zambia could contribute to increase production of meat and milk by 57 to 80 percent in the future (2012-2030 compared to past period 2000-2011) under constant climate and by 49 to 71 percent in a drought scenario. The same interventions also help to reduce inter-annual variability from 17 percent in biomass to 11 percent in animal products in a drought scenario. Finally, emissions per unit of products are reduced by 25 percent with the interventions in a drought scenario. Those results confirm the very high potential for climate-smart solutions in the livestock sector in Zambia. A fourth component is focusing on a socio-economic analysis of the impact of different agricultural solutions under climate change.

Case study 13: Plan of action for Disaster Risk Management in the Lao People's Democratic Republic[62]

The Ministry of Agriculture and Forestry (MAF) in the Lao People's Democratic Republic is highly committed to moving towards a more proactive approach to disaster risk management. In 2013, it initiated an interactive DRRM stakeholder consultation process which led to the development of a Plan of Action for DRRM in agriculture (2014–2016). Drawing on key priorities embedded in existing policies and regulatory frameworks, the Plan of Action identifies priorities and working mechanisms for enhanced risk reduction in agriculture, livestock, forestry and fisheries. FAO facilitated the DRRM stakeholder consultation and planning process among several technical departments in MAF and its affiliated research institute, the Ministry of Natural Resources and Environment and the National Disaster Management Office, as well as several international organizations. The planning process was informed by a DRRM system analysis in four regions. MAF has endorsed the Plan and implements currently selected priority actions in high-risk provinces with technical assistance from FAO.

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[61] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

[62] Food and Agriculture Organization of the United Nations (FAO). 2016a. Climate Change and Food Security: Risks and Responses. FAO, Rome. Available online at http://www.fao.org/3/a-i5188e.pdf

Case study 14: Adaptive regional fisheries management in the Western Pacific Ocean[63]

Skipjack and yellowfin tuna fisheries in the equatorial waters of the western Pacific Ocean make important contributions to the global supplies of fish and to the economies of Pacific island countries (PICs). The 1.3 million tonnes of tuna caught each year from the exclusive economic zones (EEZs) of PICs supply 25 percent of the world's canned tuna; license fees from foreign fishing fleets contribute up to 10–40 percent of government revenue for several small island nations; and locally based tuna fishing vessels and canneries account for as much as 20 percent of the GDP of some PICs. But the effects of the El Niño-Southern Oscillation (ENSO) on the distribution and abundance of these two species of tuna make it difficult to know when and where these important benefits will occur. During La Niña events, tuna catches are greatest in the western part of the region. During El Niño episodes, the best catches are made further east.

To keep catches within sustainable bounds, and optimize the distribution of economic benefits, the eight PICs where most of the tuna are caught control and distribute fishing effort by the purse-seine fishery through the 'vessel day scheme' (VDS). These eight countries are known as the Parties to the Nauru Agreement (PNA)* The VDS sets a total allowable effort within PNA waters. This total effort is allocated among the EEZs of PNA members, based on historical average patterns of fishing. Members are able to trade fishing days between themselves to cater for situations where the fish, and hence fishing vessels, are unusually concentrated either in the west or east due to the influence of ENSO events. The trading component aims to ensure that all PNA members continue to receive some level of benefits from the fishery, regardless of where tuna are concentrated. The VDS not only allows the purse-seine fishery to deal with climatic variation, it has the flexibility to allow the fishery to adapt to climate change. Allocation of vessel days to PNA members based on fishing effort history is adjusted regularly. Therefore, as the projected redistribution of tuna to the east occurs under the changing climate, the periodic adjustment of allocated vessels days will reduce the need for members to trade fishing days.

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[63] www.fao.org/3/a-i3325e/i3325e10.pdf. Module 10.

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