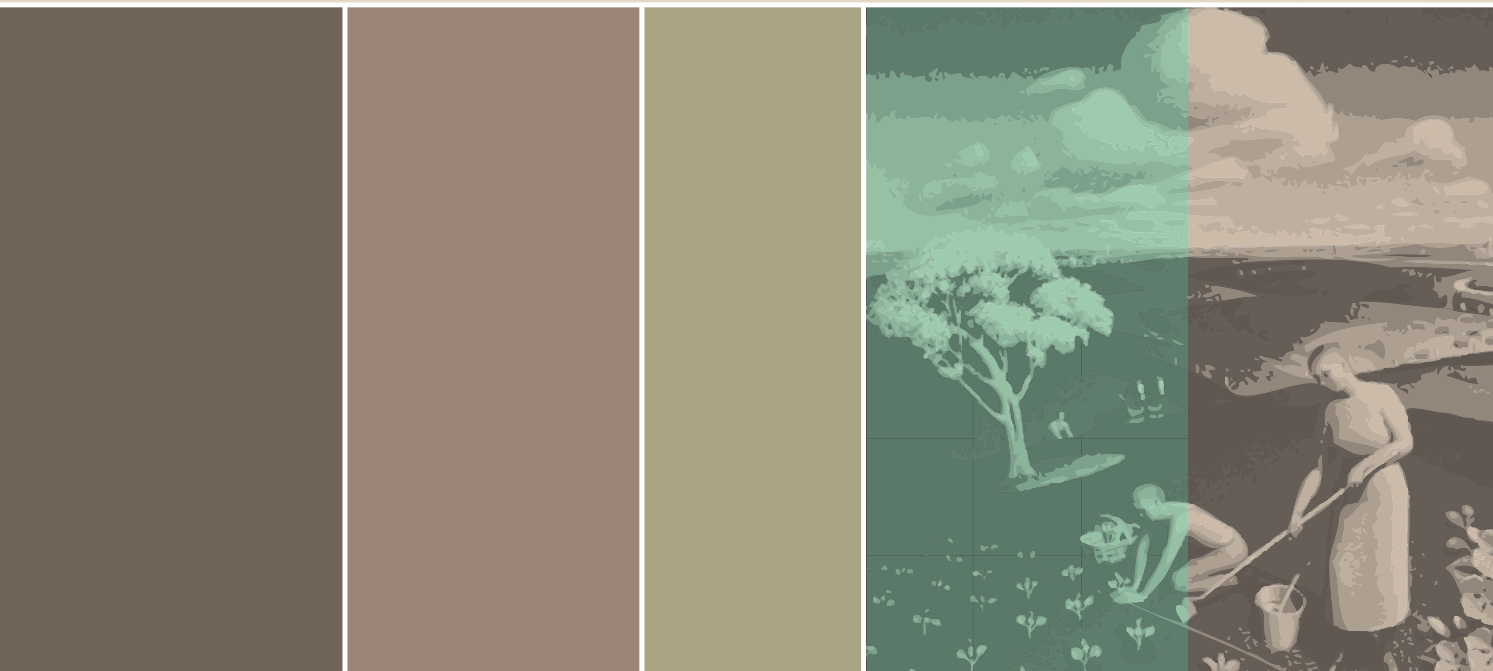


# COPING WITH CLIMATE CHANGE: THE IMPORTANCE OF GENETIC RESOURCES FOR FOOD SECURITY



COMMISSION ON  
GENETIC RESOURCES  
FOR FOOD AND  
AGRICULTURE







To provide food and nutrition security when confronted with the challenges of climate change we will have to confront new problems, often unpredictable, and without precedent. The safeguarding and sustainable use of the genetic resources of plants, animals, forests, invertebrates and microorganisms are key to maintaining our ability to achieve food security through proper agriculture, forestry, fisheries and aquaculture practices.

It is essential to link climate change adaptation and mitigation policies and programmes to genetic resources objectives while simultaneously considering the need for food and nutrition security. Access to and development and use of a wide portfolio of genetic resources will serve as the essential insurance policy that enables responses to future changes in production conditions. In this way, genetic resources for food and agriculture will serve as the security net for our food.

It is both important and urgent to take into account the importance of genetic resources for food and agriculture in addressing adaptation measures and food security. These issues shall be considered within the work on adaptation to be undertaken as decided in Cancun and in the Nairobi work programme, with appropriate linkages to the work of relevant international organizations and national best practices.

## CLIMATE CHANGE AND GENETIC RESOURCES

**E**stablished in 1983, the Commission provides the only permanent forum for governments to discuss and negotiate matters specifically relevant to biological diversity for food and agriculture. The Commission aims to reach international consensus on policies for the sustainable use and conservation of genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use. As of June 2011, 173 countries and the European Union are members of the Commission.

The Commission on Genetic Resources for Food and Agriculture requested that FAO carry out studies on the potential of genetic resources for food and agriculture for adaptation to and mitigation of climate change. Sectoral analyses on the state of knowledge, on the risks, and on the potential of genetic resources for food and agriculture in the face of climate change were prepared. Selected highlights of these sectoral studies are presented in this document.



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The text of the United Nations Framework Convention on Climate Change states that stabilization of greenhouse gas concentrations in the atmosphere should be within a timeframe, which *"ensures that food production is not threatened"*. Climate variability and change have been and are expected to be more rapid and intense than previously thought, requiring both quicker and more profound adaptation.

Agriculture, fisheries, forestry and the natural resources on which they depend, will be challenged to ensure the food security of an increasing number of people during this century - an additional three billion people by 2050, requiring an estimated 70 percent increase in global food production. This will have to be carried out under changing climatic conditions, especially in the most vulnerable parts of the developing world. In these areas in particular, adaptation of agriculture, fishery and forestry sectors will not be an option but an imperative for survival. Yet, within the present international policy arena on climate change, the role of agriculture is not prominent, although greater efforts are being made by some Countries and Organizations to position agriculture firmly in the global negotiation process. Efforts to develop a work programme on agriculture within the Subsidiary Body on Science and Technology of the UNFCCC have not yet reached the full agreement of the Parties.

While the UNFCCC recognizes the important role of forests and other terrestrial and marine ecosystems in tackling climate change, most efforts to date have focused on climate change mitigation activities, with little explicit consideration of the roles of forest genetic resources or other genetic resources in mitigation and, especially, in adaptation measures. The role of plant, animal and aquatic genetic resources is not specifically addressed under the UNFCCC, nor is the genetic diversity of micro-organisms and invertebrates.

While there is a clear understanding in the agricultural sector about the need to maintain and sustainably use genetic diversity in order to respond to ever-changing production conditions, there is an urgent need for heightened awareness of the roles and values of genetic resources in the context of climate change and the overall capacity of agriculture to respond to climate change. The understanding of this relevance of genetic resources to climate change is crucial, especially among those currently engaged in the climate change policy discussion and debate.

An inadequate consideration of genetic resources in planning and implementing adaptation and mitigation measures is largely due to a lack of awareness. However, this could be a key moment to influence the debate and increase awareness about the role genetic resources could play in the climate change adaptation and mitigation. The Commission already transmitted the studies on genetic resources and climate change to the High Level Panel of Experts on Food Security and Nutrition of the UN's Committee on World Food Security, as a contribution to their ongoing study on climate change and food security."



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## IMPACTS OF CLIMATE CHANGE ON AGRICULTURE

Impacts of climate change on agriculture have been identified in various studies. Climate change will cause shifts in areas suitable for cultivation of a wide range of crops, studies revealed a general trend of loss in suitable area in sub-Saharan Africa, the Caribbean, India and northern Australia, and gains in the northern USA, Canada and most of Europe. Although farmers have always adapted their cropping systems to adverse climatic and environmental conditions, the speed and complexity of climate change pose a new magnitude of problems. New within-crop diversity will be needed to adapt to future conditions, and under extreme conditions new crops will be required. Adapting crop varieties to local ecological conditions can reduce risks induced by climate change, but the need for adapted

germplasm is urgent and requires characterization, evaluation, and the availability of materials now housed in genebanks.<sup>1</sup>

It is also expected that climate change will result in increased demand for water and energy in the livestock sector. Animals' water requirements increase with temperature. However, under climate change scenarios, water will become notably scarcer and its availability less predictable. Heat stress also adversely impacts livestock – reducing appetite, production and fertility, and increasing mortality rates. This is particularly concerning as in some cases long-term single-trait selection for yield has given rise to animals with lower heat

tolerance.<sup>2</sup> Research has found that as milk yield in dairy cattle has risen, and growth rates and leanness in pigs and poultry have increased, the animals' metabolic heat production has increased and their capacity to tolerate elevated temperatures has declined.<sup>3</sup> This may give rise to the need to adjust breeding goals or for breed or species substitution.

Ecological dynamics and equilibriums are likely to be affected. Potential consequences include asynchrony between pollinators and crop flowering, enhanced pathways for invasive alien species, and improved conditions for pests and parasites. As temperatures rise and lead to range and phenological changes, it is reasonable to expect that the distribution and abundance of arthropods, including vectors of diseases, will generally be altered, thereby affecting disease transmission.

Despite many uncertainties and unknowns, there is a growing consensus that climate change could lead to an overall increase in the abundance and diversity of invertebrate pests – and pest pressure – as habitats become more favourable for their establishment and development and new niches appear.<sup>4</sup> Furthermore, studies suggest that increases in temperature, even if small in magnitude, may have a negative impact on tropical insects, including beneficial insects, because they may already be living in an environment very close to their optimal temperature.<sup>5</sup> Hosts and pathogens may be brought together in new locations and contexts, bringing new threats to crops, livestock and aquaculture systems, and new challenges, with the accompanying need for significant human and financial investments to address the challenges.

In aquatic ecosystems, the most severe effects of climate changes will be felt by populations in restrictive circumstances. Examples include farmed fish in ponds, pens, cages and raceways; and wild or stocked fish in shallow lakes and reservoirs, and streams and rivers in conditions of low flow and stagnation; as well as in shallow coastal waters, with special habitat features and communities, such as those of coral reefs, sea grass beds and agricultural wetlands. Aquatic ecosystems and their biota account for the largest carbon and nitrogen fluxes on the planet and act as its largest carbon sinks. In addition to the continuous rain of calcifying micro-organisms to the ocean floor, the calcium carbonate in the skeletal structures of marine invertebrates, particularly echinoderms, and the carbonates precipitated in marine fish intestines make huge contributions to global carbon storage.<sup>6</sup> Disturbances caused by climate change could adversely impact this essential ecosystem service.

The effects of climate change will also depend on current production conditions. Areas already being impacted by other stressors, such as pollution, or areas where production levels are at or near upper levels of sustainability, will likely be impacted earlier and more significantly by climate change. Production systems that rely on highly selected genetic resources might be increasingly vulnerable to climate change impacts such as disease spread. If production levels decrease, there could be pressure to cultivate



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marginal lands and risks of increased unsustainable practices that over the long-term, degrade lands and resources, and adversely impact biodiversity on and near agricultural areas. In this regard, already food insecure people in the developing countries will be most adversely affected by climate change.

## RESPONDING TO CLIMATE CHANGE WITHIN THE AGRICULTURE SECTOR – GENETIC RESOURCES AS A BASIS FOR ADAPTATION

A much broader vision of risk management is needed, especially as climate changes are expected to have potentially catastrophic effects on food production in many developing countries. While such changes may be relatively gradual and occur over the mid to long term, action is urgently needed now in order to allow the necessary timing for building the necessary resilience of agricultural production systems. A key measure, among others, is to develop staple food varieties with heightened adaptation to future climatic conditions. To do this, genetic material existing both *in-situ* and *ex-situ* (including that of their wild relatives) needs to be conserved before it disappears to breed better climate-adapted crops, livestock, fish and trees.

Experts indicate that 30 percent of the world's countries will experience a new climate with a new combination of factors such as temperatures, rainfall, winds and daylights, while other parts of the world could experience a climate already existing somewhere else. Genetic resources for food and agriculture, as well as the knowledge attached to their proper use, will have to position itself accordingly for the benefit of the new users in order to adapt to these changes.

Indeed, responding to climate change will not be effective if the focus is solely on a particular resource rather than on the overall production system, the agriculture ecosystem and its associated biodiversity.<sup>7</sup>



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The impacts of climate change for the management and use of **plant genetic resources** for food and agriculture are likely to place new pressures on conservation of landraces of crop species. Consolidating collections of wild species is important as they can be a key resource for climate change adaptation, providing researchers breeders and natural resources managers with genes and traits for biotic and abiotic resistance. Genetic material in genebanks plays an increasingly important role for adapting agriculture to climate change, including for screening for different characters.<sup>8</sup> Overall, strategies and approaches are needed to facilitate the adaptation of agricultural systems to climate change through better management of crop varieties and seed systems.<sup>9</sup>



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In **crop production**, maintaining genetic diversity has long proven to be an essential strategy to reduce and prevent impacts of crop diseases.<sup>10</sup> This is also relevant to abiotic stresses, such as salinity and drought. While it is difficult to predict the precise effects that climate change will have on the distribution and severity of pests and diseases, greater genetic variation across space and time could potentially reduce disease transmission and the effects of crop pests.<sup>11</sup>

Conservation of **invertebrate genetic resources** useful to agriculture and food is necessarily based on whole organisms *in situ*. Healthy agricultural ecosystems will provide much of this, but natural habitats as a source of soil invertebrates, biological control agents and pollinators will also be important, in as yet unpredictable ways.<sup>12</sup> Increases in CO<sub>2</sub>, changes in water availability and increases in temperature will alter plant chemistry, phenology, growth and distribution, and these changes in the physiology, form and biomass of plants will in turn alter the quality and composition of the leaves, which can affect the growth and development of herbivores and of those organisms that prey on them.

The amount of **carbon in the soil** will be increased and decreased by the action of soil invertebrates and micro-organisms, and if this could be managed so as to increase carbon in the soil it might provide a means of reducing atmospheric CO<sub>2</sub>.<sup>13</sup>





**Agroforestry systems** are examples of agricultural ecosystems with high structural complexity that can offer advantages in the context of global warming. Although the primary crops of economic interest (coffee, cacao) are sometimes grown in more intensively managed systems with little shade cover, the more structurally complex systems have been shown to buffer crops from large fluctuations in temperature,<sup>14</sup> thereby keeping crops in closer-to-optimal conditions. The more shaded systems have also been shown to protect crops from lower precipitation and reduced soil water availability<sup>15</sup> because the overstory tree cover reduces soil evaporation and improves soil water infiltration. Moreover, agroforestry systems also protect crops from extreme storm events (hurricanes, tropical storms, etc.) in which high rainfall intensity and strong winds can cause landslides, flooding and premature fruit drop from crop plants.<sup>16</sup>



In the **livestock sector**, many generations of natural selection and human-controlled selective breeding and husbandry in a wide range of production environments, have given rise to great genetic diversity expressed as species, breeds and populations that are adapted to a diverse range of conditions, including extreme climates and severe disease and parasite challenge. This diversity, which can potentially play an important role in adapting livestock production to the effects of climate change, is largely maintained *in situ* within small-scale livestock production systems by farmers or pastoralists.<sup>17</sup>

Most adaptation by **aquatic organisms**, wild and farmed, to the stressors associated with climate change is being accomplished through natural selection to their changed and more changeable environments. The most important traits, which are highly interactive, include: fecundity; tolerance to lower water quality (in terms of available oxygen, acidification, increased or reduced salinity, increased turbidity and siltation, and increased levels of pollutants) and resistance to diseases, parasites and toxic blooms; as well as, particularly for aquaculture, the commercial traits of fast growth, good feed conversion and high product quality.<sup>18</sup>



In the context of climate change, aquaculture and fisheries will have to place increased reliance on species, stocks and genetic strains that can live and perform adequately in a wide range of environments. For ecological and economic reasons, this will favour the use of fish that feed at lower trophic levels and that have relatively short production cycles. In warmer waters of variable quality, air-breathing species will have increased potential, especially in aquaculture.

## AN ECOSYSTEM APPROACH TO BEST MEET THE CHALLENGES OF CLIMATE CHANGE

The ecosystem approach calls for an adaptive approach to management. This will be essential because adaptation and mitigation measures in diverse agricultural systems will require learning and adjusting over time, as knowledge is gained and as impacts are better understood. Understanding how the entire dynamic of the system is affected by climatic change is crucial. For example, predicting and responding to potential impacts on **pollination, soil biodiversity, and pest and disease outbreaks** and spread are essential to maintaining and enhancing agricultural production. An adaptive approach will necessitate enhanced efforts to predict impacts on agricultural production systems and to model the relationships between climate change and the distribution of specific genetic resources. This will facilitate the identification of geographical areas where agro-ecological shifts driven by climate change are most likely. Once identified, the most vulnerable locations and resources can be targeted for more in-depth investigation and the tailored development of strategies for adapting production to changing conditions.



## SAFEGUARDING GENETIC RESOURCES AS AN ESSENTIAL INSURANCE POLICY

Although the full impacts of climate change cannot be predicted with certainty, there is no doubt that access to and development and use of a wide portfolio of genetic resources will remain the essential insurance policy that enables responses to future changes in production conditions.

As most food production systems experience the impacts of climate change, the affected countries will be urged to seek common, internationally coordinated solutions. Such solutions will include a reliance on diversity, either of the species currently in production or of new species entirely, often coming from other countries. The need to maintain genetic diversity will only grow with the severe and rapid changes that are anticipated due to climate change.

It is also important that policy-makers keep in mind that climate change will increase the interdependence of countries in the use of genetic resources for food and agriculture, especially when developing policies and financial instruments for the adaptation of ecosystems, including agro-ecosystems, to climate change.<sup>19</sup>

## WAY FORWARD

As a result of the studies carried out in 2010, the FAO Commission on Genetic Resources for Food and Agriculture agreed on a roadmap for its future work on climate change and genetic resources for food and agriculture based on four elements: i) strategies and policies; ii) tools and technologies for genetic resources and climate change; iii) forging partnerships; and iv) monitoring progress.

The Commission also:

- invited the UNFCCC to consider inclusion of genetic resources in UNFCCC areas of work such as in the implementation of the programs of work on loss and damages, the Nairobi work program, the work of the Committee on technologies, and the project of a work program on agriculture under the Subsidiary Body for Scientific and Technological Advice; and
- encouraged Countries to consider available information about the importance of including the management of genetic resources for food and agriculture in planning and implementing their countries' National Adaptation Programmes of Action and Nationally Appropriate Mitigation Actions.





## ENDNOTES

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