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SGRP

The Impact of Climate Change on Countries' Interdependence on Genetic Resources for Food and Agriculture

An Executive Summary

The System-wide Genetic Resources Programme (SGRP) of the CGIAR coordinated the development of a Background Study Paper entitled 'The Impact of Climate Change on Countries' Interdependence on Genetic Resources for Food and Agriculture' for the Twelfth Session of the FAO Commission on Genetic Resources for Food and Agriculture. The purpose of the paper was to contribute to the Commission's consideration of policies and arrangements for access and benefit-sharing for genetic resources for food and agriculture. This document is an executive summary of that paper. The table of contents and authors are reproduced in Box 1.

Introduction

This paper investigates the impact that climate change will have on countries' interdependence on genetic resources for food and agriculture. The extent of countries' interdependence on categories or sectors of genetic resources is an important consideration when evaluating and/or developing policies and norms oriented to the conservation, management, access to and use of such resources.

Climate change

With respect to climate change, the most relevant prediction for this study is that, on average, global temperatures will likely increase worldwide by 0.2 degrees per decade. There will be both increases and decreases in precipitation. Droughts and floods will increase (IPCC 2007). The areas with climates that are now suited to a particular suite of crops, forages, livestock, trees, microbes, and aquaculture will shift in ways that are more favourable to a minority of countries and less favourable to the majority.

Climate modelling indicates that growing season temperatures in the tropics and subtropics by 2099 will be greater than the extremes recorded from 1900 to 2006. The hottest season to be recorded in the temperate regions will become the norm in many places. Extreme seasonal heat will severely lower the output of production systems (Battisti and Naylor 2009).

Looking ahead to 2050, the effects of global warming for maize, millet, and sorghum in Africa, for example, will be disastrous and will require concerted responses in crop breeding and the conservation of crop genetic resources:

"The majority of African countries will have novel climates over at least half of their current crop area by 2050. Of these countries, 75 percent will have novel climates with analogs in the current climate of at least five other countries, suggesting that international movement of germplasm will be necessary for adaptation. A more troubling set of countries – largely the hotter Sahelian countries – will have climates with few analogs for any crop (...) countries, such as Sudan, Cameroon, and Nigeria, whose current crop areas are analogs to many future climates but that are poorly represented in major gene banks – [provide] promising locations in which to focus future genetic resource conservation efforts (Burke et al. 2009)."

Climate change will be highly variable around the world. According to current models some countries/ regions will actually benefit as a result of having more, longer growing days as well as increased rainfall. These countries are in the minority. Most countries will experience climate change that work to their disadvantage, with temperature increases, longer droughts, and increasingly frequent, violent storms exacerbating stresses that have already been challenging their agricultural production systems. Based on existing models, it is reasonable to predict that as all countries' climates change, most countries' climates will become more similar to one another, with only a few countries' climates becoming, relative to the situation today, more different from most other countries' climates. As such, many countries may be headed towards common future conditions, leaving relatively fewer countries that can provide the genetic resources for needed food system adaptation to climate change in the future.

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Countries' interdependence on genetic resources for food and agriculture

Interdependence on genetic resources for food and agriculture (GRFA) refers to the extent to which individual countries rely upon GRFA originally collected from other countries in support of their food and agriculture-related research, conservation and production[1].

The idea that countries are interdependent on GRFA is not new and has been documented in numerous studies (Frison & Halewood 2006). Countries' interdependence on plant genetic resources for food and agriculture (PGRFA) is evident in the international pedigrees of most modern crops and forages, which include 'parents' from numerous different countries and continents (Zeven and De Wet 1982, Gollin 1998, Cassaday *et al.* 2001). Countries' interdependence on PGRFA is also evident in the international movements of germplasm facilitated by international genebanks and research stations. In the course of just 12 months, the Centres of the Consultative Group on International Agricultural Research (CGIAR) facilitate the international movement of approximately 450,000 samples of PGRFA, 80% of which is sent to developing countries, mostly to public agricultural research programmes (SGRP 2009). Interdependence on PGRFA is also evident in the fact that many major crop staples are now grown around the world, far from their centres of origin. Crops were domesticated over thousands of years in areas of the world that are now "developing" countries or regions. Interestingly, however, the adaptations of diets of people around the world has taken place to such an extent that most countries and regions – including those in centres of diversity – are heavily reliant on non-indigenous, imported germplasm of staple crops from other parts of the world. For example, southern Africa is more than 90 percent dependent on "outside" crops (Palacios 1998). Cassava is a major food source in Africa today (FAO 1997), while African millets and sorghums are major food crops in south Asia and Latin America (Kloppenburg and Kleinman 1987). The extensive cattle pastures of Latin America depend largely on African grasses (Miles *et al.* 1996; Boonman 1993). Alfalfa from south western Asia is now cultivated around the globe (Putnam *et al.* 2009). Forestry has also long benefited from the international movement of tree germplasm (Koskela *et al.* 2009).

The case is similar for livestock, with the private sector heavily involved in the international movement of farm animal genetic resources. Livestock producers have relied on the international exchange of genetic resources throughout human history. Analyses of animal genetic resources trade flows from 1990 to 2005 for 150 countries show that Europe and North America were the primary exporters of genetic resources for the species evaluated. North-South trade had the largest magnitude, followed by South-South, and, finally, South-North. Southern genetic resources are not currently used on a large scale in the North (Gibson and Pullin 2005; FAO 2007).

The management of aquatic resources has always reflected some degree of international collaboration simply because fish are free living and highly mobile, and the water bodies and aquatic ecosystems in which they live do not follow national boundaries. The limited number of major aquaculture species has been associated with considerable movement of genetic resources to areas having suitable ecological conditions around the globe. Over the past 100 centuries, agriculture has been characterized by an increasingly wider movement of crops, forages, farm animals, and, more recently, trees and fish.

This study does not attempt to quantify baseline levels of interdependence and use this data to calculate quantified increases in that interdependence, but simply to assess whether climate change will result in countries requiring GRFA from outside their borders as part of their strategies to adapt (and, in some cases, to mitigate) climate change. Assuming all other demands remain equal, an increase in demand for resources from outside countries would result in an overall increase in interdependence. A decrease in demand would lead to a decrease in interdependence.

Hypothesis and method

Experts working in the conservation and use of crop, forage, tree, animal, microbial and aquatic genetic resources were asked to (1) describe and evaluate existing evidence (positive or negative) that climate change has increased or will increase countries' interdependence on the genetic resources concerned; (2) identify whatever gaps may exist in the literature that limit our ability to fully assess the impact of climate change in this way; and (3) summarize their final conclusions. The sector-specific studies were then compared for illuminating differences or similarities.

A significant constraint faced in this research derives from the fact that numerous interrelated factors affect the way in which GRFA needs to be managed and used. It is difficult, and sometimes impossible, to isolate climate change-related influences from those of other variables. The influence of climate change on countries' interdependence on GRFA is embedded in a broader, very complex range of variables. As a result it was often not possible to isolate simple cause and effect relationships between climate change and interdependence.

Main findings

By and large, the balance of evidence supports the hypothesis that climate change will indeed lead to an overall increase in countries' levels of interdependence on genetic resources.

Crops and forages. Germplasm interdependence will perhaps be the greatest for crops, augmenting the already high (and well-documented) international movement of PGRFA that has been taking place for a long time. Interdependence on PGRFA will likely increase in association with adaptive crop improvement achieved through both conventional plant breeding and biotechnological methods. Interdependence will also increase as climate change creates the need to adopt new crops in particularly stressed areas – millets and sorghum in the place of maize, for example.

Trees. Countries' interdependence on tree germplasm will likely increase as a result of the future demands for genetic resources in support of both tree plantation and agroforestry use, both of which will require the adoption of new species and improved, better adapted varieties. Small-scale agroforesters will be especially reliant on externally facilitated access to introduced materials because their own abilities to find, test, and adopt new trees will likely be inadequate relative to the pace of climate change.

Livestock. As is the case for crops, forages, and trees, research to identify or develop livestock breeds that are better adapted to abiotic stresses will continue to be important. Germplasm movement in modern times has been facilitated largely through the private sector, and such movements will likely increase as climate change forces redistribution of breeds to match future conditions.

Microbes. Microbial genetic resources – which are discovered, identified, isolated, sometimes genetically modified, and reproduced rather than bred – will play an extremely important role in future climate-changed scenario. On the one hand, crop diseases and disease vectors will likely redistribute and intensify as climate changes and as crops, crop cycles and crop distributions also change. On the other hand, researchers will need to respond with microbial-based solutions to ongoing and new problems in the form of, for example, specific pathogens or parasites to counter insect pests and vectors of plant diseases. The success of such research efforts will depend upon continued global public access to microbial resources.

Aquatic resources. Aquatic germplasm resources interdependence is discussed in a somewhat unique fashion because the transboundary nature of aquatic ecosystems means that aquatic resource management is necessarily interdependent. Germplasm exchange of the few aquacultural species discussed will continue largely through commercial channels. The implications for climate change-related interdependence are unclear because it does not appear that breeding for new climate-related conditions will be a major part of future strategies.

The fact that the rate of climate change will likely exceed many organisms' adaptive capacity is a common denominator for all of the sectors studied. The case is most strongly made with respect to crops and forage varieties, animal breeds, and tree populations. The evidence is less conclusive for beneficial microbes and aquaculture species, but there are anecdotal accounts that point in this direction, and it is logical to expect that it should be so, although the greater mobility of organisms in these sectors could be a mitigating factor.

The gap between the rate of climate change and the organisms' adaptive capacities will require significant adjustments in national agricultural production systems and planning. As some countries' climates gradually become more like other countries' present climates, they will be able to turn to portfolios of crop and forage species, varieties, livestock breeds, trees, microbes, and fish that are currently used in the latter countries.

As most countries – particularly poor countries in areas already suffering drought, high temperatures, and devastating storms – move into having climates without precedent in the history of agriculture, they will be pushed together to seek common, internationally coordinated solutions. Such solutions will include reliance on "outside" sources of diversity, either of the same species currently in production or of new species entirely.

The impact of climate change vis-à-vis pathogenic microbes is, in some respects, the corollary of its impact on crops, forages, livestock, and trees. Climate change will provide opportunities for pathogenic microbes (and their insect vectors) to thrive in parts of the world where previously they have had no, or only limited, impact. The effect will be to augment countries' dependence upon genetic resources from beyond their borders – in this case, as sources of genetic resistance to novel pests and diseases or as bio-control agents.

Internationally coordinated efforts involving international movements of germplasm and associated information will be critical for countries' to be able to meet the challenges associated with climate change.

It is critically important for policy makers to keep increasing interdependence on GRFA in mind when developing policies concerning the conditions under which genetic resources are conserved, managed, accessed and used, and the ways in which benefits derived from their use are shared.

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Endnotes

1 The extensive network of ex situ collections of genetic resources (not only plant genetic resources for food and agriculture but also sizeable collections of microbial genetic resources and, to a lesser extent, tree, animal, and aquatic genetic resources) means that countries may not need to physically have access to materials located within the borders of a particular country. It may be that material once collected from country X is available from collection Y, which is located in another country. The actual location of the material, once collected, does not affect the extent to which its use in other countries reflects interdependence.

Box 1. The Impact of Climate Change on Countries' Interdependence on Genetic Resources for Food and Agriculture.

Background Study Paper No.48. FAO Commission on Genetic Resources for Food and Agriculture. Fujisaka, S., Williams, D. and M. Halewood (eds). 2009. FAO, Rome.
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Introduction

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Crop and forage genetic resources: international interdependence in the face of climate change.

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Tree genetic resources: international interdependence in the face of climate change.

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The impact of climate change on animal genetic resources and country interdependence.

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The impact of climate change on interdependence for microbial genetic resources for agriculture.

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