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CLIMATE CHANGE AND DEVELOPMENT

CONSULTATION ON KEY RESEARCHABLE ISSUES

SECTORAL ISSUES
SECTION 2.1. AGRICULTURE AND FOOD SECURITY
LAUREL MURRAY

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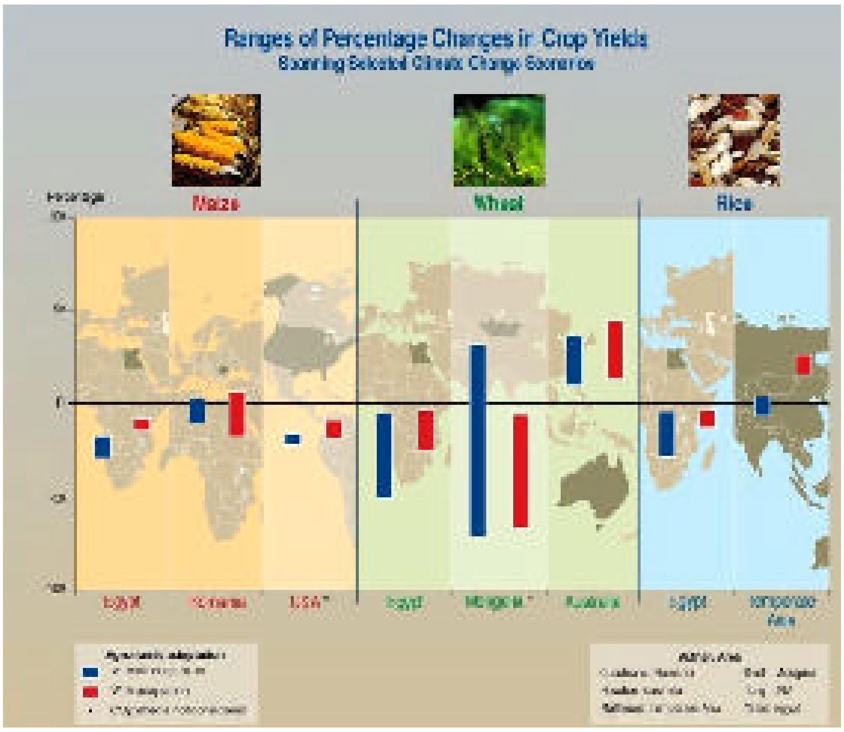
Climate Change, Agriculture and Food Security

The last 50 years has seen a rapid growth in agriculture yields with current global food supply exceeding demand. However, this growth has not been gifted to all parts of the world. Many countries are experiencing diminishing crop and rangeland productivity attributed to such factors as rising populations and changing demographics, land degradation, price shocks, HIV/AIDS, credit arrangements, and climate variability. Least developed countries, especially in sub-Saharan Africa, are dangerously food insecure making agriculture a primary focus for development efforts. Moreover, globalisation and diminishing terms of trade are a concern where agriculture is a large GDP contributor. Climate change will have both positive and negative impacts on agriculture and future food supply. Certain sectors and regions may benefit from changing climate conditions, opening up new opportunities. However, many poorer countries, especially those in the tropics and sub-tropics, will face increasing vulnerability, threatening food security. It is for this reason that climate change must be included in agricultural development programmes.

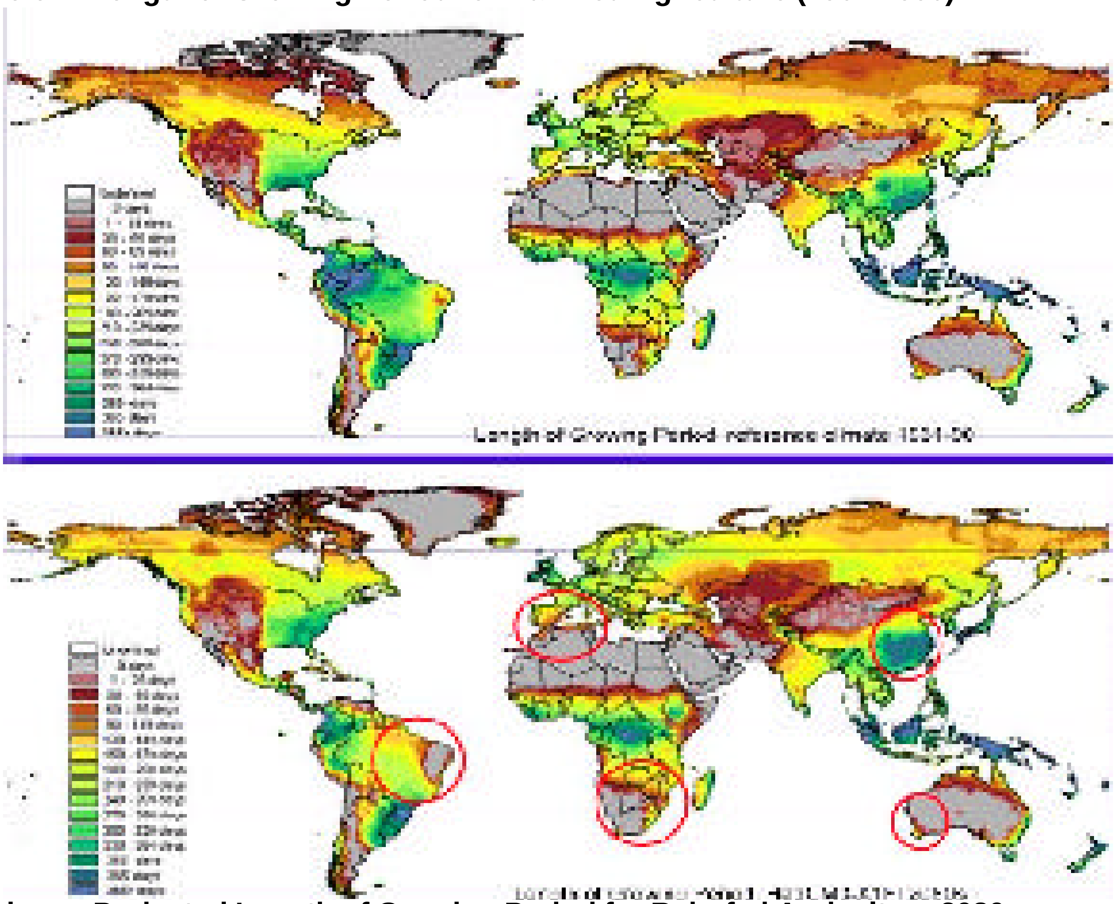
Figure 1: Changing Crop Yields Under Climate Change*



* Taken from IPCC TAR 2001

Fortunately, there is a wealth of literature exploring climate change impacts and agriculture. In fact, agriculture is a dominant research area within the climate change community; and increasingly, climate change is also being taken up in agriculture development studies. This can be attributed to the historical relationship between agriculture and climate science and the direct applicability of climate model data to the agricultural sector (Arnall, *et al.*, 2004). On the other hand, research in the past has focused on understanding climate change impacts in agriculture rather than adaptation (Arnall, *et al.*, 2004); although adaptation is steadily becoming a popular research theme (See Smit, Burton, Klein, etc.). Research also favours commercial agriculture, with significant research gaps with respect to climate change and subsistence farming.

Below: Length of Growing Period for Rain-fed Agriculture (1961-1990)



Above: Projected Length of Growing Period for Rain-fed Agriculture 2080.

Climate Change Impacts on Agriculture and Food Security

Climate change impacts on agriculture and livestock will depend on changes in temperature, precipitation, sea-level rise (leading to salinisation of croplands), and climate variability (such as erratic rainfall, floods, droughts, and ENSO-related events). The complex interaction of these variables make it difficult to predict how climate change will impact at the regional level; however, Figure * provides an illustration of possible changes in crop yields published by the IPCC (2001). "One generalisation is that, in most cases, the existing disparities in crop production between developed and developing countries [are] estimated to increase" (Hitz and Smith, 2004, p205). Warmer temperatures will favour northern, developed countries and open up new croplands in many temperate and boreal regions. In contrast, southern, developing countries (especially in parts of North and southern Africa) are likely to experience shorter, drier growing seasons, and possibly more frequent drought that would undermine crop productivity and worsen existing water stress. There are also more indirect climate change impacts such as an increased risk of livestock pests attributed to changes in temperature and precipitation. The text box “Implications of climate change for agriculture, food security and poverty in the Sahel region” provides an illustration of how climate change will impact food insecure regions such as those in sub-Saharan Africa, and the challenges facing development and adaptation policies.

Figure 2: Climate Change and Agriculture Interactions (adapted from Chiotti and Johnston, 1995)

Climate Change Impacts:

First-order Effects:

- Changes in the length of growing season and period of crop growth
- Changes in crop yields and livestock productivity
- Changes in sensitivity to inputs (i.e fertilizers and pesticides)
- Spatial shifts of moisture limits, crop potential and comparative advantage

Concurrent biophysical effects:

- Water resources
- Soil fertility (from increased nutrient leaching) and soil erosion (rates of wind erosion).
- Areas such as the Sahel may get drier. This would lead to less leaching, more hard setting of soils and more laterization.
- Distribution and incidence of pests and diseases

Higher-order effects:

- Farm profitiability and regional farm income
- Regional and national food production and production costs
- Rural employment, society and settlement
- Food supply, food security, prices and trade
- Parallel effects in other sectors
- Migration

Adjustments and policy responses to climate change:

Farm level:

- Changes in landuse: amount of farmed area, crop variety, and crop location
- Changes in management: irrigation use, fertilizer applications, pest control, soil drainage, control of erosion, land topography, farm infratsrtcutre, crop and livestock husbandry.

Regional and national:

- Changes in regional landuse allocation
- Changes in national agricultural policy: to maintain food security, equitable regional farm incomes, and support of farm inputs.
- Increased poverty
- Women’s issues
- Reduced development opportunities

Implications of Climate Change for Agriculture, Food Security, and Poverty in the Sahel Region
Source: Serigne Kandji, ICRAF

Achieving food security and reducing poverty in the Sahel has been a major challenge for both governments and development agencies. Per capita food production has followed a declining trend over the last two decades, exposing an increasingly high number of people to food insecurity and income poverty (FAOSTAT data, 2004). Currently, 40 percent of people in the Sahel region are considered food insecure. This unfortunate situation is the result of many factors, some of which are: (1) the inherently poor nature of soils (most soils are sandy, low in carbon and poor in nutrients); (2) the rapid population growth (3 percent per annum) that has led to continuous cropping, expansion of agriculture into marginal areas, and overgrazing; (2) the low use of technologies such as improved varieties, fertilisers, mechanisation and irrigation that have stimulated agricultural development elsewhere in the world; and (4) the absence of adequate technologies and policies that take into account the specific needs of the small scale farmers of Africa..

The Sahel region will be particularly vulnerable to climate change because of its geographic location at the southern edge of the Sahara desert, its fragile ecosystems, and the high dependence of its population on rainfed agriculture and livestock. The agricultural sector employs between 75 and 90 percent of the active population depending on country, and contributes close to 35 percent of the Gross Domestic Product (GDP) of the region. Yet, agriculture in semi-arid regions is a highly risky enterprise due to unreliable and variable rainfall. More than anything else, farmers often struggle to produce enough food for their own subsistence, leave alone generating any kind of income from farming activities.

The recurrent droughts of the 1970's and 1980's (the 'desiccation') represented a particularly trying episode for the Sahelian countries, with massive shortfalls in agricultural and livestock production resulting in the loss of human lives to hunger, malnutrition and diseases, the apparition of environmental refugees, and the collapse of national economies (Batterbury and Warren, 2001; Mortimore and Adams, 2001). Yet, most climate models predict that the Sahel region will be drier in the 21st century. Even slight increases in rainfall will do nothing to reverse the situation since a hotter climate means that evapotranspiration will be more intense, exacerbating the already arid conditions (see national communications of the Sahelian countries to the UNFCCC). Thus, if action is not taken immediately, food deficits will be more pronounced, aggravating an already preoccupying food and nutritional situation (Mendelsohn et al., 2000; Butt et al., 2003). In fact, climate change is likely to become the greatest obstacle to the achievement of food security, poverty reduction, and other Millennium Development Goals (MDGs) to which the Sahelian countries have subscribed.

Addressing the entangled issues of food insecurity, poverty and environmental degradation in the Sahel is therefore a matter of great emergency, especially with the prospect of climate change. One salient aspect of climate change, however, is that nobody knows exactly the magnitude (and sometimes direction) of the changes in climate variables, especially precipitation. Climate models are based on scenarios and can, at best, give a range of possible (sometimes conflicting) outcomes. This can make the design of adaptive options for the future a difficult task. The focus, therefore, should be on how to develop a mix of no-regret technology options and policies geared at promoting the emergence of productive, sustainable, and flexible agricultural systems that show enough resilience regardless of the direction and magnitude of climate change. Another important question is how relevant the adaptive methods and strategies that are used now and are effective in coping with current stresses will be in the occurrence of climate change. Whereas modelling exercises have allowed us to have a better understanding of the likely behaviour of cereals and other crops when the climate changes in the future, there has been little emphasis on tree-based systems. For instance, agroforestry provides a rich set of promising technologies that can (biophysically and economically) buffer against current climate variability and food/income risks, but little is known about the possible impacts of higher temperatures, increased atmospheric carbon dioxide and shift in rainfall pattern on the agroforestry tree species on the one hand, and on their interactions with food crops on the other hand. For example, in a drier or warmer climate tree–crop competition for water could intensify. What will be the trade-offs between this type of effects and positive impacts such as microclimate effects and soil protection? The research community, together with policy makers and developments agencies, should start to think about this kind of outcomes. Otherwise, there is a high risk of losing the gains of agricultural research to climate change. Given the fact that the lives of millions of people are at stake and that research is a medium- to -long-term process, we can hardly afford to adopt a wait-and-see attitude.

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Implications of Climate Change on the Food Security in Bangladesh
Source: Z. Karim (Executive Director, Arannayk Foundation) and S.G. Hussain (Chief Scientific Officer, Bangladesh Agricultural Research Council)

The Third Assessment Report of the IPCC considers agriculture as one of the most vulnerable systems to be affected by climate change in the south Asian region. Bangladesh being one of the countries of the region and a flat deltaic floodplain, it is very likely that the climate change vulnerability would increase. The agriculture sector; including crops, livestock and fisheries sub-sectors contributes a major share to the GDP, which is about 30% and employs more than 60% of the working force. The climate of Bangladesh is generally sub-tropical in the north to hot humid in the south. Southwest monsoon influences the climate during June to October, and during the winter the climate is controlled by the northeast monsoon from November to March. The summer is hot and humid and the winter is mild. The country is vulnerable to many environmental hazards, including frequent floods, droughts, cyclones, and storm surges that damage life, property, and agricultural production. Limited studies indicates large impact on agriculture, which would make the poor more vulnerable in respect to food security.

During the period 1961 to 1991 four population censuses were conducted. According to these census, the population has almost doubled in less than 30, and is likely to double again in another 35 years. Currently, the estimated population stands at over 135 million. To keep pace with population growth and shrinking land resource base, the food production needs to be doubled by the year 2020. Sustainable growth and development of agricultural sector is the important issue to the government for meeting the future challenge of increased production.

To predict the consequences of climate change on agriculture limited efforts have been made to generate climate change scenarios and using various Global Climate Models (GCMs) and DSSAT (Decision Support System for Agrotechnology Transfer) based Crop Simulation models of International Consortium for Agricultural Systems Applications (ICASA). Due to unavailability of high resolution GCMs for Bangladesh as well as for the South Asia region reliable scenarios cannot be generated. On the other hand, for running different crop models, various required minimum datasets for crops, management, and climatic parameters are not collected adequately or incomplete. Another aspect of these efforts is validation of the output from these models, which is very important. To make reliable predictions the model outputs need to be thoroughly substantiated with evidence.

The important problems arising from climate change impact on food security in Bangladesh are the following:

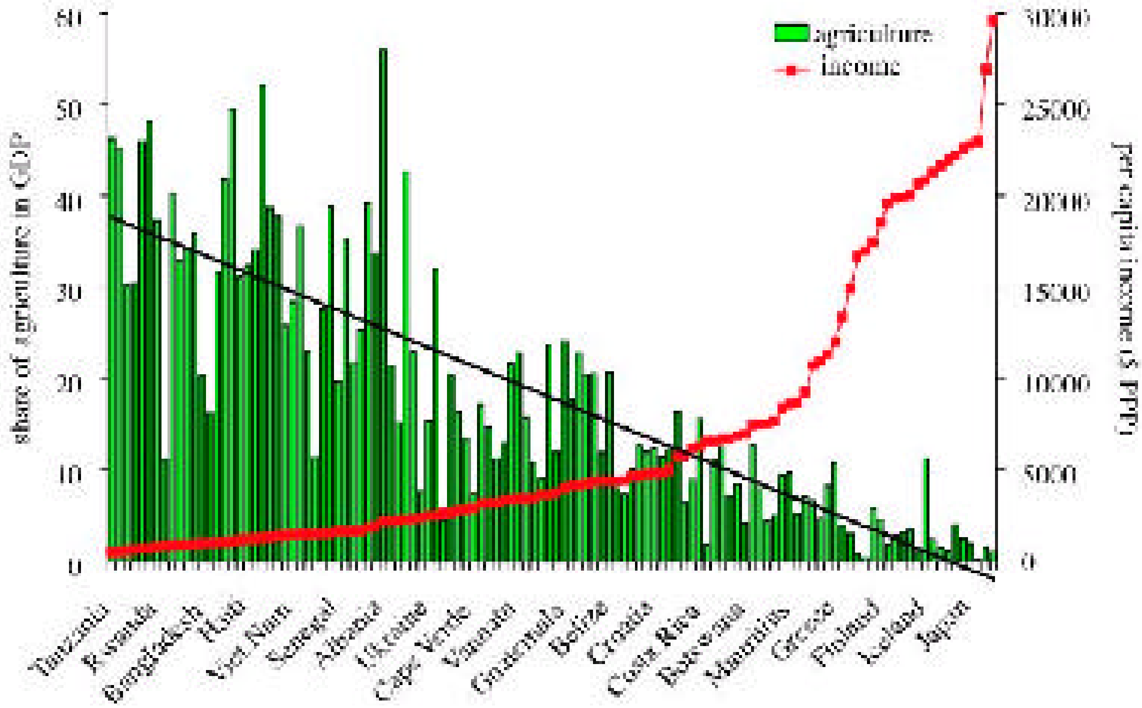
- Bangladesh has 4.72 million ha of coastal area of which 2.39 million ha is exposed to the sea. The total coastal area represents about 31 % of the country's total land surface.
- Most of the agricultural crops (rice, wheat, tubers, vegetables, etc.) and fisheries are severely vulnerable to climate change by rise in temperature, and intensification of droughts and floods in different seasons.
- Currently more than 35 million people are living in the coastal area and by 2020 there will be more than 44 million and they are likely to be affected as the changed climate would alter agricultural practices and farming systems of the area.
- There would be severe erosion of biodiversity as most of the plant species either wild or cultivated are vulnerable due to rise in temperature and increase in inland salinity.
- Very limited adaptation measures or capacity building programs has been initiated for developing coping capacity for the people living in the coast.

In order to address the above problems, immediate research priorities are as follow:

- Information available on the climate change impacts on agriculture requires validation in order to generate packages of adaptation measures for agricultural production.
- A working group should be formed involving all relevant organizations GOs and NGOs so that the required data/information could be collected/generated. A National facility should be developed to conduct phytotron (plant growth chamber) experiments under simulated climate change scenarios.
- Since climate change and Sea Level Rise will have adverse effect on the ecosystems, many important germplasm are likely to be destroyed. Research should be initiated to preserve the vulnerable species of crop, fisheries, and livestock. Genetic tolerance to adverse environment/improvement must be achieved in order to have sustainable food security and development. Research should be undertaken for screening of genotypes for withstanding adverse edaphic, environmental, and climatic conditions; and also developed/introduced low moisture consuming crops/cropping patterns
- In combating the agricultural vulnerability to climate change and sea level rise, remote sensing and GIS technologies should be used.

Before addressing interlinkages between the climate change and agriculture sectors, it is worth emphasising the prominent place agriculture holds in development policy because of its contribution to GDP, balance of payments, employment, and livelihood. In particular, livelihood concerns and food security are especially significant for poorer countries. Food security is both a function of agriculture and livestock production *and* food purchasing power. As such, climate change will have a direct impact on food production, and indirect consequences for purchasing power.

Figure 3: The Share of Agriculture in GDP and per capita income in 1995*



* Taken from R.S.J. Tol, *et al.* (2004), p265.

Research into Climate Change Impacts, Adaptation and Agriculture

The climate change science community has long studied climate change impacts and vulnerability to agriculture and there is a wealth of data and studies dating back to the 1990s. However, as stated above, the complexity of meteorological factors make it difficult to predict climatic changes at the regional level and their subsequent effect on agriculture and food security. For instance, climate change impacts on agriculture may not progress along a linear path. Unlike coastal impacts which will grow continuously over time in proportion, more or less, with rising sea-levels; agricultural impacts may follow a hump-shaped curve with short-term benefits under moderate warming turning into losses under more substantial climate changes (Tol *et al.*, 2004; Berkhout, 2004; Hitz and Smith, 2004). Another area of uncertainty is the interaction of climatic trends (such as gradual changes in CO_2 levels, temperature, and precipitation) with climate variability (such as droughts, floods, and ENSO-related events) (Devereux and Edwards, 2004). There are also key questions about system thresholds, where gradual changes may exceed unknown thresholds and cause ecosystem collapse (Devereux and Edwards, 2004). These inherent uncertainties make regional modelling very difficult and limit the ability of scientists to provide more specific projections that would inform adaptation and development policy. In addition, the lack of policy initiatives in many developing countries to climate change and agriculture can be traced to general sense of apathy (Bryant *et al*., 2001; Smit *et al*., 2001) to uncertainty about whether regional impacts will materialise and/or magnitude (Kurukulasuriya and Rosenthal, 2003). Another possible explanation for the lack of policy outcomes is the fact that price support schemes continue to drive local agricultural operations (Lorenzoni *et al*., 2001).

In addition to changes in climate, climate adaptation policies must also consider social and economic factors such as population growth, urbanisation, trends in cropland expansion, human and livestock diseases, biotechnology, water management, and economic globalisation. These socio-economic factors coupled with physical changes in climate will ultimately determine future crop and rangeland productivity and food security. The development community has a long research tradition studying such socio-economic factors which would provide a more comprehensive picture of climate change vulnerability and adaptation options. For example, agricultural geography has long studied agricultural systems at the local to global level, examining the role of landuse planning, institutional arrangements, inter-regional interactions, and social trends such as urbanisation (Chiotti and Johnston, 1995). Another research area includes decision-making behaviour to understand how communities and farmers make decisions and may prove helpful for assessing farming coping and adaptation strategies. Political economy is another research stream that investigates the structural factors influencing agricultural sectors such as the internationalisation of agriculture, changes in agribusiness interests, and adjustments/responses to changing economic conditions. These are but some of the various approaches within agriculture and development that can help inform climate change adaptation research and policy. The main argument is that an interdisciplinary understanding is needed, and there are promising signs that the climate change and agricultural fields are sharing more.

Within climate change adaptation and agriculture, there are many areas of research and policy being explored. Understanding the attributes of agriculture most sensitive to climate, the types and combinations of climatic events most harmful to farming, the nature of farmer responses to climatic risks and uncertainty to change, and the role of other forces as mediating these response factors. The area of livelihood response strategies is particularly promising because of its applicability to adaptation and development policy.

Technology development and testing will also be required. Promising improved agricultural practices need to be tested for their ability to buffer against the impacts of climate change and climate variability as well as for their ability to respond to the concerns of farmers. We can deduce from first principles which practices are likely to contribute to the sustainability of farmers' livelihoods, but data will be required to develop an understanding which technologies produce real benefits and where they fare likely to perform best. Key technologies that deserve testing include water harvesting, conservation tillage and agroforestry.

Table 1: Typology of Adaptation Options in Agriculture*

1. Micro level adaptation such as farm production adjustments (i.e. diversification and intensification), changes in landuse and irrigation; and timing of farm operations, management of seed banks, response to information and climate forecasts, pest/disease control, remittances, and changes in technology (both in crop varieties and farming activities).
2. Market responses such as crop and flood insurance, investment in crop shares and futures, credit schemes, and diversification opportunities.
3. Institutional changes (including government responses) such as pricing adjustments and subsidies, development of stabilisation options, insurance, agricultural support and insurance programmes, and improvements in agricultural markets and inter-regional trade.

* Adapted from Kurukulasuriya and Rosenthal, 2003

Traditional Farming Systems, Agrobiodiversity and Climate Adaptation
Source: Professor José Ireneu Furtado, Imperial College of Science, Technology & Medicine

Traditional farming systems rich in agrobiodiversity abound where both biodiversity and ethno-diversity are rich, often in mountainous or rugged terrain, where communities are marginalized by socio-economic and/or biophysical conditions. These systems exhibit remarkable landscape mosaics, ingenious resource management and recycling techniques, intricate conservation measures for intra- and inter-specific variability, and ecosystem resilience and robustness that enable traditional communities cope with unexpected environmental and socio-economic changes and alleviate risk. They, in turn, reinforce traditional knowledge and customs that make these communities cohesive and somewhat self-reliant. However, these farming systems and the agrobiodiversity they conserve are threatened by economic globalization and global climate change through a range of locally variable factors, such as the penetration of global consumer media in remote markets, agricultural intensification for commodity markets through price subsidies, chemical inputs and/or high-yielding exotic varieties (including genetically modified organisms), policy and market distortions primarily through high agricultural subsidies in the industrialized countries and the low prices paid for agricultural commodities, neglect in R&D and knowledge generation for sustainable rural development linked to urban markets, and climate change (both variability and extremes) in terms temperature, precipitation and/or storm events. These threats induce traditional knowledge and cultural erosion, natural resource overuse and degradation, productivity declines, agrobiodiversity loss and the substitution with exotic varieties, and/or distinct changes in agro-ecological zones, resulting in food insecurity, unsustainable livelihoods and urban migration. There is an urgent need to understand the nature of traditional knowledge and socio-cultural and economic factors that enable remote traditional societies harness agrobiodiversity and natural resources to promote ecosystem resilience and robustness that alleviates risk and provides the key ingredients for adaptation to unexpected disasters, since they have a bearing on climate adaptation.

Critical Problems / Questions:

- What is the agrobiodiversity composition and pattern in traditional farming systems, their interactions with ecosystem goods and services at the landscape level, and local knowledge and customs that promote the use, management and conservation of natural resources for sustainable rural livelihoods and risk alleviation?
- What biophysical and socio-economic threats, and policy, regulatory and institutional distortions (national / provincial), challenge the sustainability and hence adaptability of traditional farming systems, and what critical countervailing reforms are needed for revitalizing their adaptive capacity?
- How can linkage to niche markets promote the sustainability of traditional farming systems, agrobiodiversity conservation and adaptive capacity to environmental changes?

Priority Research Areas:

- Rotational or shifting agriculture: agro-forestry with hill rice (South East Asia, Eastern Himalayas, Southern India, Madagascar); with maize (Latin America); with sorghum and millet (East, Southern & West Africa)
- Flood plain and irrigated agriculture: recession agriculture (most floodplains); wet rice, aquaculture and small livestock husbandry (China, South East Asia, India, Amazon basin); floating rice (Bangladesh, Nigeria, Chad); maize, root crops and small livestock husbandry (Chinampas in Mexico and the Andes; Waru-waru in the Andes); coastal taro-based systems (Pacific islands); stone fruit-based systems (eastern Mediterranean and Trans-Caucasian regions); oasis-based systems (Middle East, North Africa)
- Multi-layered home gardens in the tropics (China, South East Asia, Papua New Guinea. India, East & West Africa, Amazon basin)
- Pastoral *transhumance*: semi-arid regions (West and East Africa, India, China, Mongolia); mountainous regions (Alps, Carpathians, Andes, Pamir and Himalayan chains); tundra-taiga regions (Russian Siberia, Yukon)

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