Food security: Antagonistic Effects of Climate Change

Dr. P.V. Ramesh Babu, Research Associate, Central Research Institute for Dry land Agriculture, Santhosh Nagar, Hyderabad
Dr. G. Vijay Kumar, District Consultant APSWIP, Prakasam Dt.
A. Chandrakala, Subject Matter Specialist, ATMA, Prakasam Dt
D.G.M. Saroja , Technical Officer CRIDA, Hyderabad.

ABSTRACT

Climate is a primary determinant of agricultural productivity. Temperature, precipitation, atmospheric carbon dioxide content, the incidence of extreme events and sea level rise are the main climate change related drivers which impact agricultural production. Indian agriculture is fundamentally dependent on climate for higher productivity. The problems of Indian Agriculture are urbanization of farmland, water rights and usage, environmental concerns and the procurement of government subsidies. The environmental impacts of ecological diseases causes land erosion, loss of soil fertility, depletion of nutrient reserves, salinization and alkalinization, pollution of soil and water systems, loss of crop, pest resurgence and genetic resistance to pesticides, chemical contamination and destruction of natural control mechanisms. It is clear that there is no choice but to produce more with less. Environmental sustainability in agriculture is no longer an option but an imperative. There are three crucial environmental challenges in the agriculture sector; conservation of biodiversity, mitigation of climate change and the global shift towards bio-energy.

1. Introduction

Food insecurity and climate change are already inhibiting human well-being and economic growth throughout the world and these problems are poised to accelerate.29 Countries vary in their vulnerability to climate change, the amount and type of GHGs they emit and their opportunities to reduce GHG emissions and improve agricultural productivity. According to scientific survey, in order to meet global demands we will need 60-70 per cent more food by 2050. The Director of Central Food Technological Research Institute (CFTRI) reported that every one degree rise in temperature is reducing agricultural yield by 10%, and rice and wheat are some of the important victim crops of climate change. Rice production in India could decrease by almost a tonne per hectare if the temperature goes up 2^0C, while each 1^0C rise in mean temperature could cause wheat yield losses of 7 million tonnes per year (Beddington *et al,* 2012).

Before the introduction of Green Revolution, the country faced massive food shortages and depended heavily on food imports and aid. The current food scenario is completely the changed. Now we are producing huge food grain surpluses that tend to accumulate as public buffer stocks to the extent that the government is subsidizing exports of grain. Recent data shows that except for edible oils and pulses, import dependence is extremely low for most agricultural commodities. Net availability of cereals has been on an increasing trend and that of pulses is on a decreasing trend over the years. In the recent years since 1996 there appears to be a declining trend in the per capita net availability of cereals (Howes and Murgai, 2003). In the case of pulses the trend has been a secular decline in per capita net availability. Increases in food production were mainly achieved by the use of high yielding varieties (HYVs) of rice and wheat, accompanied by expansion of irrigated areas. More than the expansion of cultivated area, rise in productivity was responsible for this phenomenal increase in production. Government policy which included subsidies on fertilizers, irrigation and power along with price support for the produce played an important role in achieving self-sufficiency in food grains.

2. Food Security as a Social Right

India is now one of the world's leading producers of rice and wheat and emerged as a regular exporter of rice in recent times. However it continues to depend on imports for its requirements of pulses and edible oils. It is the biggest producer of milk in the world and ranks among the top producers of fruits and vegetables. Its production of exportable horticultural products has risen sharply in recent years. India is a net exporter of agricultural products. Its exports include rice, oil meals, cotton, coffee, fruits, vegetables and marine products. Imports include edible oils, pulses, dried fruits, and nuts. Currently we are in a paradoxical situation where huge food surpluses at the aggregate national level coexist with large undernourished and poor population. Aggregate cereal consumption trends as given by the past rounds of national sample surveys indicate that total consumption of cereals is on a declining trend. Most of this is due to the decline in the consumption of coarse cereals as the consumption of rice and wheat remained stagnant or even decreasing. The prices of cereals have been growing at faster rate compared to other commodities. The increase in prices is evident even for the food grains supplied through PDS . The rising trend in procurement prices of wheat and rice led to increases in food prices from the whole sale to retail level. What do these aggregate trends mean in terms of nutrient intakes? A comparison of results from the latest two consumption surveys indicates that per capita nutrient intakes of households have not improved much between 1993-94 and 1999-2000 (Umali-Deininger and Deininger, 2001). Intake levels of both calories and proteins remained below the corresponding levels of recommended dietary allowance (RDA). Fat intake increased in both rural and urban areas between the two time points. Although the urban intake is above the RDA the rural intake remained below RDA. In terms of stability of nutrient availability we see that the supply of calories from cereals has become more stable in the recent decades Agriculture could also have a negative influence on food security outcomes as agricultural incomes are relatively more uncertain. The net impact of agriculture could be positive or negative and can be resolved only empirically.

3. Synergistic effects of Climate Change on Agriculture

The increased global temperature coupled with CO_2 content may likely to increase the crop production to a certain limit. Food security lies not only huge production of food grains but also its judicious distribution to cope with upliftment of socio-economic conditions of impoverished people. To adapt to climate change and ensure food security, major interventions are required to transform current patterns and practice for food production, distribution and consumption. The scientific community has an essential role to play in informing concurrent, strategic investments to establish climate resilient agricultural production systems, minimize greenhouse gas emissions, make efficient use of resources, develop low-waste supply chains, ensure adequate, encourage healthy eating choices and develop a global knowledge system for sustainability. Hence, the World Bank presents cross-country econometric evidence to show that investment in agriculture, in which smallholder farmers participate as managers and labourers, has double the impact on poverty reduction as investment in any other sector. Future impacts of climate change on the incomes and food security of poor households will very much depend on whether resultant losses in agricultural yields are local or widespread. Moreover, climate is not the only determinant of food security: rapid environmental, economic and political changes may be connected globally but have disparate impacts in different locales. Agriculture is also a major contributor to greenhouse gas emissions both directly and as a proximate driver of land use change (Subramanian and Deaton, 1996). The challenge is to mitigate these emissions without compromising food and livelihood security.

4. Antagonistic effects of Climate Change on Agriculture

Average temperature effects are important, but there are other temperature effects too. Increased night-time temperatures reduce rice yields, for example, by up to 10 percent for each 1°C increase in minimum temperature in the dry season. Increases in maximum temperatures can lead to severe yield reductions and reproductive failure in many crops. In maize, for example, each degree day spent above 30 °C can reduce yield by 1.7 percent under drought conditions. Higher temperatures are also associated with higher ozone concentrations. Ozone is harmful to all plants but soybeans, wheat, oats, green beans, peppers, and some types of cotton are particularly susceptible. Changes in temperature and rainfall regime may have considerable impacts on agricultural productivity and on the ecosystem provisioning services provided by forests and agro forestry systems on which many people depend. There is little information currently available on the impacts of climate change on biodiversity and subsequent effects on productivity in either forestry or agro forestry systems. Globally, the negative effects of climate change on freshwater systems are expected to outweigh the benefits of overall increases in global precipitation due to a warming planet. The atmospheric concentration of CO_2 has risen from a pre-industrial 280 ppm to approximately 392 ppm in 2010, and was rising by about 2 ppm per year during the last decade. Many studies show that there is a CO_2-related yield increase ("CO_2 fertilization") for C_3 crops but that this effect is limited, if not insignificant, on C_4 plants such as maize and sorghum. There remains considerable uncertainty about the impact of increased CO_2 concentrations on plant growth under typical field conditions. While increased CO_2 can have a beneficial effect on yields, it might also affect negatively nutrient composition for the crop (see discussion below) and also depends on whether plant growth is limited by other factors such as water or nutrients. In some crops such as bean, genetic differences in plant response to CO_2 have been found, and these could be exploited through breeding. Increased CO_2

concentrations lead directly to ocean acidification, which (together with sea-level rise and warming temperatures) is already having considerable detrimental impacts on coral reefs and the communities that depend on them for their food security.

Vegetables are generally sensitive to environmental extremes and high temperatures and limited soil moisture are the major causes of low yields in the tropics. These will be further magnified by climate change. Little is known in general about the impacts of climate change on the pests and diseases of crops, livestock and fish, but they could be substantial. Within some limits, insects reproduce more rapidly with higher temperatures, and are more likely to over winter in temperate locations. Many weeds perform well under increased CO2 concentrations. For example, yams and cassava are crops that are known to be both well adapted to drought and heat stress (Mruthyunjaya *et al*., 2002), but it is thought that their pest and disease susceptibility in a changing climate could severely affect their productivity and range in the future. Potato is another crop for which the pest and disease complex is very important and how these may be affected by climate change (including the problems associated with increased rainfall intensity) is not well understood.

Climate change will result in multiple stresses for animals and plants in many agricultural and aquatic systems in the coming decades. There is a great deal that is yet unknown about how stresses may combine. For example, in rice there is some evidence that a combination of heat stress and salinity stress leads to additional physiological effects over and above the effects that each stress has in isolation. Most studies of the biological effects of climate change on crop production have focused on yield. A second impact, much less studied, is how the *quality* of food and forages are affected by climate change; i.e., the composition of nutrients in the individual food items and the potential for a changing mix of foods as crops and animals respond in different ways to a changing climate. Grains have received the most attention – with both higher CO_2 levels and temperature affecting grain quality (Srinivasan and Jha 2001).

5. Consequences of Climate Change and Agriculture on Food Security

The food system faces additional pressure as the global population grows to around 9 billion by 2050. This dramatic increase in global population will be accompanied by major shifts in the regional distribution of our planet's inhabitants. From 2010 to 2050, the population in Asia is estimated to grow from 1 billion to 2.2 billion. From 1950 to 2050, the population ratio for developing countries to developed countries is projected to shift from 2:1 to 6:1. as the world population has grown, the land available per capita has shrunk from 13.5 ha/person in 1950 to 3.2 ha/person in 2005, and is projected to diminish to 1.5 ha/person in 2050. Food systems contribute 19%–29% of global anthropogenic greenhouse gas (GHG) emissions, releasing 9,800–16,900 mega tonnes of carbon dioxide equivalent ($MtCO_2e$) in 2008 (Ahluwalia 1993). Agricultural production, including indirect emissions associated with land-cover change, contributes 80%–86% of total food system emissions, with significant regional variation. The impacts of global climate change on food systems are expected to be widespread, complex, geographically and temporally variable, and profoundly influenced by socioeconomic conditions. Historical statistical studies and integrated assessment models provide evidence that climate change will affect agricultural yields and earnings, food prices, reliability of delivery, food quality, and, notably, food safety. Low-income producers and consumers of food will be more vulnerable to climate change owing to their comparatively limited ability to invest in adaptive institutions and technologies under increasing climatic risks (Dev, 1995). Some synergies among food security, adaptation, and mitigation are feasible. But promising interventions, such as agricultural intensification or reductions in waste, will require careful management to distribute costs and benefits effectively. Low-income producers and consumers of food will be more vulnerable to climate change owing to their comparatively limited ability to invest in adaptive institutions and technologies under increasing climatic risks. Some synergies among food security, adaptation, and mitigation are feasible. But promising interventions, such as agricultural intensification or reductions in waste, will require careful management to distribute costs and benefits effectively.

6. Specific recommendations

Apart from the obvious focus needed on soil health, water conservation and management, and pest management, agriculture and food production will need to become sustainable and ecologically sound to adapt to climate change turbulence. A special package for adaptation should be developed for rainfed areas based on minimising risk. The production model should be diversified to include crops, livestock, fisheries, poultry and agro forestry; homestead gardens supported by nurseries should be promoted to make up deficits in food and nutrition from climate-related yield losses; farm ponds, fertilizer trees and biogas plants must be promoted in all semi-arid rainfed areas which constitute 60% of our cultivated area. (Gaiha, R., 2000). A knowledge-intensive rather than input-intensive approach should be adopted to develop adaptation strategies. Traditional knowledge about the community's coping strategies should be documented and used in training programmes to help find solutions to address the uncertainties of climate change, build resilience, adapt agriculture, and reduce emissions.

Conserving the genetic diversity of crops and animal breeds, and its associated knowledge, in partnership with local communities, must receive the highest priority. Breed improvement of indigenous cattle must be undertaken to improve their performance since they are much better adapted to adverse weather than high-performance hybrids. Balancing feed mixtures, which research shows has the potential to increase milk yields and reduce methane emissions, must be promoted widely. An early warning system should be put in place to monitor changes in pest and disease profiles and predict new pest and disease outbreaks. The overall pest control strategy should be based on integrated pest management because it takes care of multiple pests in a given climatic scenario. A national grid of grain storages, ranging from pusa bins and grain goals at the household/community level to ultra-modern silos at the district level, must be established to ensure local food security and stabilise prices. Agricultural credit and insurance systems must be made more comprehensive and responsive to the needs of small farmers. For instance, pigs are not covered by livestock insurance despite their potential for income enhancement of poor households. The following adaptation and mitigation support structures should be established at each of the 128 agro ecological zones in the country (Haddad, 2000). A centre for climate risk research, management and extension should prepare computer simulation models of different weather probabilities and develop and promote farming system approaches which can help minimise the adverse impacts of unfavourable weather, and maximise the benefits of a good monsoon. A farmer field school to house dynamic research and training programmes on building soil health, integrated pest management, water conservation and its equitable and efficient use. The school should engage in participatory plant and animal breeding; there should be a focused research programme to identify valuable genetic traits like drought-, heat- and salinity-tolerance and disease resistance available in the agro biodiversity of the region. Village resource centres with satellite connectivity from where value-added weather data from the government's Agromet service should be made available to farmers through mobile telephony, giving them information on rainfall and weather in real-time. A network of community-level seed banks with the capacity to implement contingency plans and alternative cropping strategies depending on the behaviour of the monsoon. Decentralised seed production programmes involving local communities, to address the crisis of seed availability. Seeds of the main crops and contingency crops (for a delayed/failed monsoon, or floods) as well as seeds of fodder and green manure plants specific to the agro ecological unit must be produced and stocked. Technical and financial investments must be made in climate adaptation and mitigation research. Some priority areas identified by the conference are:

- Evaluation of traditional varieties and animal breeds for valuable traits like tolerance to higher temperatures, drought and salinity, feed conversion efficiency and disease resistance, for use in breeding new varieties and breeds.
- Developing balanced ration and feed-and-fodder regimes that will increase milk yields of indigenous cattle and reduce methane emissions.
- Participatory and formal plant breeding to develop climate-resilient crop varieties that can tolerate higher temperatures, drought and salinity.
- Developing short-duration crop varieties (especially wheat) that can mature before the peak heat phase sets in.
- Selecting genotypes in crops that have a higher per day yield potential to counter yield loss from heat-induced reduction in growing periods.
- Developing (the more heat-tolerant) durum wheat varieties for rabi cultivation in north India, to supplement diminishing wheat yields from existing wheat cultivars, and for durum wheat's chapatti making qualities.

To adapt to climate change and ensure food security, major interventions are required to transform current patterns and practices of food production, distribution and consumption. The scientific community has an essential role to play in informing concurrent, strategic investments to establish climate-resilient agricultural production systems, minimize greenhouse gas emissions, make efficient use of resources, develop low-waste supply chains, ensure adequate nutrition, encourage healthy eating choices and develop a global knowledge system for sustainability.

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