Food security: The challenges of climate change and bioenergy

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Agriculture must supply all people with enough food to prevent widespread hunger and starvation. However, food security is aggravating day by day, resulting in more number of undernourished/malnourished persons in the world. The ever-increasing population in the developing and less developed countries is also a major constraint. With climate changes in future, natural calamities (drought, flood, forest fire, fluctuation in rainfall pattern, etc.) will be a serious threat to human survival by way of availability of foods. Moreover, if food plants (cultivated and wild species) are utilized for the production of renewable liquid biofuel, there would be enormous changes in agroecosystems, destabilizing the natural balance and leading to lower productivity of food crops.

The World Food Day celebrated every year on 16 October gives an impetus to food security, but the major challenges are to be surpassed for human welfare. Food security means an access by all people at all times to enough food for an active, healthy life. It is a basic right of everyone to adequate diet. At present, food security in India is insecure and may probably collapse in future, because food is not available with the recommended quantity of nutrients and the number of malnourished/undernourished persons is increasing every year[1]. Undernourishment is defined as having less than 9200 kJ of food energy per day. It has been reported by the Food and Agriculture Organization of the United Nations (FAO), that the proportion of undernourished people in developing countries has fallen from 57% in 1964–66 to 10% in 1997–99. However, with insufficiency in food supply, the population of hungry people in developing countries will increase by 1% for every 2–2.5% increase in prices, mainly because the purchasing power and high cost of food items do not match in the present scenario of economic growth. It means one has to purchase less food than required and ultimately this condition leads to increased hunger. For example, persons living below the poverty line (BPL) is around 25% in Maharashtra, whereas this proportion is only 5% in Punjab. In reality, we are passing through a transition from a surplus production supply to greater demand for staple food commodities. According to the estimates of the International Food Policy Research Institute, additional 38% rice should be produced by 2025 to satisfy the growing demand, without adversely affecting the resource base[2].

How do we solve these global and local problems? The agricultural land supplies nearly 90% of human food requirements, while occupying 12% of the earth's ice-free surface. During the last century, food production increased by about sevenfold. This was achieved with modern farm technologies (hybrid seeds, synthetic fertilizers, chemical pesticides, farm machineries, etc.). In India, by introducing the green revolution in the late sixties, the production of foodgrains could be increased fourfold, e.g. 50 mt in 1950 to 212 mt in 2006. Similarly, even though the human population grew about four-fold, the amount of food supplied by agriculture for each person on the planet was almost doubled. Therefore, adequate nourishment is possible if the food is distributed evenly across the whole world. In fact, this is not the reality, as about 10% of the population in the world is still undernourished. If this food sufficiency is to be achieved, the world food production must be about 50% greater than it was in 2000. This target seems to be difficult to achieve, as crop productivity is nearly stagnant or coming down, or if continues to increase, it would be at a much smaller rate of improvement due to several environmental changes and socio-economic situations. In fact, although human-controlled factors such as soil, seed, fertilization and plant protection can be controlled, the weather is still a key factor in agricultural productivity, and reduction in the potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization.

It is estimated that humans appropriate 25–40% of the world's terrestrial biological production for their own use. This has had implications for the other species with which we share the planet. Though an increase in food production is welcome, it would be necessary to reduce the impact of agriculture on environment. Since India is an agricultural country, farm economy should consider not only food commodities, but other agricultural productions such as textile products, medicinal plants, horticulture, forest revenues, dairy by-products and other internationally traded commodities. This is because sustainable high returns can only be generated from products that are valuable to customers. This means there is an urgent need for a transition from the present agriculture to higher-value foods.

Challenges of climate change

Maurice Strong rightly said, 'It is a matter of time that attention to climate change will be the first priority. It is a major challenge because the hardest things to change are habits of thinking and it is precisely these that stand in the way of a healthy future for the human race, not only with regard to climate change, but also many other global problems. It is also a priority because some changes require a long lead-time, so that it is important to start early in order to avoid disaster. Climate change is one such problem and it is urgent to begin addressing it'.

Climate change and agriculture are interrelated and climate change over the next century may have significant effects on crop production and food availability. It is speculated that by 2050, there would not be any glacier in the world. The melting of ice would result in frequent floods and significant rise in sea level. Floods will destroy standing crops, forest fire will be a common phenomenon in drought-affected areas, more water will be necessary for irrigation, cultivable

land will become infertile, and rainfall at regional level exhibit an increasing or deceasing trend. These changes will in turn cause deterioration of existing ecosystems. For example, the Nile river used to add soil to Egypt's arid region and land became fertile even in the desert area. The rising water level of the Mediterranean Sea affected vegetation and farming in the region. Also, changes in agrosystems will affect crop patterns. For example, there would not be enough cold in winter in the tropical countries to cultivate winter/rabi crops and it would be impossible to irrigate these crops.

It is expected that the effect of global warming will threaten about 15% of the land in the Nile delta by 2020. In South Asia also, loss of many staple food crops (rice, millet, maize) could attain a proportion of 10%. The UN Intergovernmental Panel on Climate Change (IPCC) estimated that GDP in the developing and less developed countries would decline by 1.4–3.0% due to climatic change. In India, the effects of global warming are likely to be more severe. For every 2°C rise in temperature, the reduction in GDP is 5% and for the next 6°C it would be 15–16%. Likewise, FAO has estimated that India would lose up to 125 mt of cereals. In Haryana, wheat production has declined from 4106 kg/ha in 2000–01 to 3937 kg/ha in 2003–04, with maximum temperature rising by about 3°C during February–March in the last seven years. Thus, the direct impact of climate change on agriculture and food supply includes shortage in grain production resulting in less availability of food items, especially to the economically poor people, changes in agricultural inputs such as fertilizers and pesticides, shift in planting dates of agricultural crops, preference of crop genotypes due to adaptation to changing climate, soil erosion, soil drainage and lower fertility level. Additionally, the incidence of pests, weeds and diseases in food crops will be more pronounced.

The IPCC has predicted that the greenhouse gases (GHGs) will cause temperature to increase from 1.5 to 5.8°C and precipitation patterns to shift resulting in the increase of sea water level by 15–95 cm by 2100. There would be floods on coastlines and no agricultural activities would be possible in these areas. Ultimately, people would strive for their livelihood or may move to urban areas. Moreover, the proliferation of heavy and medium industrial units and the growing urban population in India has put enormous pressure on air, water and land resources. Concentration of GHGs such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbon, etc. has been rising at a fairly rapid rate. Agriculture is the main contributor to increasing methane and nitrous oxide concentration in the earth's atmosphere. These gases prevent and absorb radiation from the earth, thereby increasing the temperature of earth's surface as well as the lower layers of the atmosphere.

The IPCC report indicated that an overall increase of 2°C in temperature and 7% in rainfall would lead to an almost 8% loss in farm level net revenue. High probability of crop losses with increase in temperature in the tropical regions is also foreseen. Water supply will suffer because of scanty rainfall in the Himalayas. According to the National Climate Centre in Pune, rainfall has decreased in July and greater rainfall has been recorded in August in key crop-growing areas of the country. Another major change in the monsoon pattern is that there has been a shift westwards, with the rainfall getting confined to certain pockets which may result in floods, resulting in the lack of food for people[3].

Challenges of bioenergy

The world is currently burning about 85 million barrels of oil per day. The demand for high-speed diesel will increase to 66.9 mt by 2011–12, which is 1.6 times higher than that of the current demand. With increasing number of vehicles and industries, the demand would further increase. Therefore, it is now imperative to search for new sources of bioenergy that would act as renewable energy. In India, development of energy from raw materials available in plenty in rural areas may be a solution to the energy security. In recent years, ethanol has emerged as the most important alternative source for biofuel due to increasing price, vulnerable supply and environmental pollution from petroleum fuel. Ethanol is mixed with gasoline to form gasohol, which contains 35% oxygen that helps complete the combustion of fuel and reduces harmful emissions. In India, a biofuel mission was started in 2003. The Government has announced a biofuel policy in September 2008 and has proposed 20% blending of biofuels by 2017.

Biofuel is produced from food crops such as rapeseed, and from edible oil extracted from rapeseed, soybean, sunflower, safflower, groundnut, mustard and palm. Oil is used for human consumption and rapeseed meal is mixed in animal feed. Further, maize, sorghum, sugar beet and sugarcane are among the list of crops that are to be utilized for bioenergy due to sucrose accumulation and may offer an excellent alternative for ethanol production. But again, these are major agricultural crops. Of course, these crops can be supplementary or complementary.

If food crops are used for bioenergy, the price of foods will be determined by their value as feedstock for biofuel, rather than their importance as human food or livestock feed[4]. India is currently providing a strong momentum for biofuel production and food production may be in jeopardy. Alternatively, we may have to import foodgrains for much higher prices and there will be less quantity of foodgrains available for humanitarian aid. Thus, alleviating hunger will no longer be solely a matter of poverty alleviation and equitable food distribution, but also a matter of food security mainly because prospects of augmenting crop productivity are rather gloomy.

Among non-edible oil sources, two forest trees, jatropha (*Jatropha curcas*) and pongam/karanj (*Pongamia pinnata*) have been selected for biofuel production in India. If plantation of jatropha is done on a large scale, the biodiversity of forest land will be reduced to a greater extent as most of the wasteland will be under these plantations. Under such a situation, pongam offers a better choice as biofuel because (i) it does not suppress any associated crop; (ii) the tree supports the activity of microorganisms in rhizosphere since root nodules fix nitrogen; (iii) it grows well in wasteland; (iv) the tree has the ability to store carbon; (v) the tree parts do not contain allelochemicals that have a harmful impact on the flora and fauna, and (vi) seed contains 30–40% oil that can be converted to biodiesel (fatty acid methyl esters).

Conclusion

The changing temperature and rainfall patterns and increasing carbon dioxide level will undoubtedly have important effects on global agriculture and thus on

food security. Assessment of the effects of climate change on agriculture might help to properly anticipate and adapt farming to maximize agricultural production. IPCC and FAO are working on climate and food supply, and by integrating agriculture and socio-economic models, they may be able to predict whether there will be hunger and famine in the coming years. Geostatistical assessment based on climate trends and actual crop yields, and assessment based on controlled conditions or crop simulation models have to be confirmed, because though atmospheric carbon dioxide enriches crop yields, there is less convincing evidence on the impact of warming temperatures. Also, the interactive effect of temperature and plant nitrogen (protein) content on respiration is not fully understood. These studies are urgently needed as the balance between food supply and food demand is shifting abruptly from surplus to deficit. Therefore, though it is imperative to produce more food in volume, we should not forget its value-addition and its impact on the environment. The choice between volume and value is to be spelt right now and should be translated into Government policies on agriculture in general and foodcrops in particular, to assure food security.

According to the IPCC, India can emerge as a leader in solar energy within the next decade and show the world a way out of global warming. With these means, the country would be free from its costly oil imports and become energy-independent. Other sources of bioenergy such as algae may also be available in future.

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