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CLIMATE CHANGE AND RAINFED AGRICULTURE : RURAL DEVELOPMENT PERSPECTIVES

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ABSTRACT

The greatest crisis ever faced by humankind is global warming and as a result the climate change. The climate change-led global warming mainly occurs due to increasing concentration of atmosphere emissions like carbon dioxide, CFCs (Chloro Flaoro Carbons), helons, methane and the nitrous oxide, resulting from various human activities. Global warming is leading to increase in variability in summer monsoon precipitation, on which 80 per cent of the Indian agriculture depends. Given the fact that a large part of the rural population of the Indian sub-continent depends on rainfed agriculture for its livelihood, it is observed that erratic monsoon precipitation would adversely affect the lives of majority of population of this region. With the productivity of irrigated lands reaching a plateau, maintaining the foodgrain production in pace with the increasing population is a real challenge. However, in the present context, the scope for horizontal expansion of agriculture is almost nil as it is already extended to marginal lands. Protogonists of climate change argue that promotion of conventional agriculture to augment the vertical expansion, will further deteriorate climate in the form of increase in global emissions through various activities of agriculture which is already held responsible for 18 per cent of global gas emissions. Hence, only vertical expansion that has to come mainly from rainfed region with sustainable and eco-friendly agricultural practices which are seen as sink for GHG emissions, is the option left to make the production viable and to meet the food security in long run. Therefore, the paper attempts to understand the impact of climate change on agriculture, with particular reference to rainfed agriculture, present policy scenario and the strategies to be adopted with in-built climate change mitigation measures, in the context of rural development.

The climate changes of geological proportions are occurring over time spans as short as a single human life time. They are happening at a time when many of the world's life support systems are already stressed by the growth of population, economy, industry and agriculture which has led to unsustainable exploitation of natural resources. The climate change-led global warming mainly occurs due to increasing concentration of atmosphere emissions resulting from various human activities. They include primarily carbon dioxide, the necessary product of combustion of fossil fuels, CFCs (Chloro Flouro Carbons)

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from refrigeration and helons from fire fighting systems, methane from the anaerobic digestion of organic matter, and the nitrous oxide from increased use of chemical fertilisers. These gases absorb and partially trap the heat radiated by the earth, reradiate some of it back to the surface, and this leads to the warming of the earth's atmosphere.

Within the last cenztury, the amount of carbon dioxide in the atmosphere has increased dramatically, largely because of the practice of burning fossil fuels – coal and petroleum and its derivatives. Presently the contribution of carbon dioxide to global warming is roughly fifty per cent and other half is due to the other gases such as methane, CFC, Nitrous oxide etc. These gases are more lethal and effective than CO_2 and consequently are dangerous even at their present trace concentration levels. Studies reveal that within the past century global temperature has increased to 1^0C (about 1.8 F). Projections of climate change as a result of the continuing emissions of carbon to the atmosphere suggest that a global warming of 1.5 to 4.5 degrees C may occur by the middle of the next century, perhaps by 2030 (WMO/ UNEP 1988).

Atmospheric scientists have now concluded that at least half of that increase in global warming can be attributed to human activity. The third assessment report of the IPCC (2001) asserted that human activities are responsible for most of the warming during at least the last 50 years. The major sectors that account for global emissions were power (24 per cent), change in land use (18 per cent), agriculture (14 per cent) transport and industry (14 per cent each) , buildings (8 per cent) (Stern committee 2007) .The recent IPCC (2007) has concluded that global temperature is expected to increase by 2.4^o C to 6.4 ^{0}C by the year 2100. The impacts of it are likely to be disproportionately varied among the nations. But most studies agree that the developing nations are highly influenced by the impacts (Mendelson et al 2006). The TAR (Third Assessment Report) of the IPCC (Inter-governmental Panel on Climate Change) draws attention to the fact that the impacts of climate change will fall disproportionately upon developing countries and also on majority of people who depend on agriculture as their main source of livelihood. The Delhi Ministerial Declaration on Climate Change and Sustainable Development, adopted at Co-p-8 (the eighth session of the conference of the parties to the United Nations Framework convention on climate change) also affirmed this. "Developing countries are particularly vulnerable … Effective and result based measures should be adopted at all levels of vulnerability, as well as capacity building for the integration of adaptation concerns into sustainable development strategies". The TAR also projects a general drying of mid-continental areas during the summer; which would lead to an increase in summer droughts. This is of relevance to India in the fact that global warming will lead to increase variability in summer monsoon precipitation, on which 80 per cent of the Indian agriculture depends. Given the fact that a large part of the rural population of the Indian sub-continent depends on rainfed agriculture for its livelihood, it is observed that erratic monsoon precipitation would adversely affect the lives of majority of population of this region. Therefore, the paper attempts to understand the impact of climate change on agriculture, with particular reference to rainfed agriculture, present policy scenario and the strategies to be adopted in the context of rural development.

Impact of Climate Change on Agriculture

The contribution of agriculture and allied activities to GDP has been decreasing from 25 per cent during 1990s to 18 per cent during 2000s. However, tremendous importance of this sector to the Indian economy can be gauged by the fact that it provides employment to two-thirds of the total workforce. Agricultural growth also has a direct impact on poverty eradication, and is an important factor in employment generation (Planning Commission 1997; 2002). During the last 60 years, foodgrain production registered an increase from 50 mt to 210 mt. One of the reasons professed for this being green revolution-based intensive package of practices. With an increase in foodgrain production the per capita net availability of foodgrains has increased from 394 gms/day in 1951 to 436 gms/day in 2008 (CMIE Agriculture 2009). The National Commission for Integrated Water Resources Development has estimated that to meet the requirements of foodgrains alone, the net sown area will have to be increased to 145 mha and the cropping intensity to 145 per cent by 2050 (Planning Commission 1997). However, there is not much scope for increasing the area under foodgrains in the country. For instance, a lot of area under rice in Kerala has been lost to cash crops like coconut and rubber. The area of foodgrains in major producing States like Punjab and Haryana has reached a plateau. Consequently, the growth of foodgrain output can be achieved only through rapid increase in productivity. That is, only, vertical expansion is possible in agriculture as there is not much scope for increase in gross sown area. Protagonists of climate change argue that promotion of conventional agriculture to augment the vertical expansion, will further deteriorate climate in the form of increase in global emissions through various activities of agriculture which is already held responsible for 18 per cent of global gas emissions. The following are the major sources of emissions of green house gases from agriculture sector:

* Fertilisers are the largest single source (38 per cent) of emissions from agriculture followed by livestock (31 per cent), wetland rice cultivation (11 per cent), (Stern Committee 2007). Nitrous oxide and methane are the important Green House Gases (GHG) being released as a result of the above activities. Fertilisers release nitrous oxide (N_20) during the natural processes of nitrification of ammonium fertilisers under aerobic conditions as well as by de-nitrification of nitrate under anaerobic conditions which may be significant in regard to the potential threat to the stratospheric ozone layer. Estimates of N_20-N emission in India ranged from 32.84 Gg (1980-81) to 93.82 Gg (2000-01) per year. There was a linear increase in emission due to increased area under different crops, higher use of N fertilisers and also increase in animal population (Bhatia. A. etal,2004).

* Livestock is the second largest source of emissions accounting for 31 per cent of agriculture emissions. Methane (CH_4) is produced as a waste product of digestion by ruminants particularly cattle, and this process is known as enteric fermentation.

* Wetland rice occupies 42 mha in the Indian sub-continent and largest in Asia, and is one of the major sources of methane emission. Indian rice fields are often blamed to be major contributors of atmospheric methane as 35 per cent of the total world's area under paddy cultivation is in India (Bhatia A. *et.al.,* 2004).

* The agriculture sector is also indirectly responsible for emissions in other sectors. It is a key driver for land use change such as deforestation which generates emissions. The production of chemical fertilisers and manufacturing of agricultural equipments requires an energy source. In addition, the

transportation of agricultural inputs and outputs leads to emissions from the industry, power and transport sectors, respectively.

It is observed that though the contribution for climate change can be attributed to agriculture which is the major source of livelihood of developing countries like India, its contribution to green house problem has been much smaller when compared to that of developed countries which are responsible for more than 60 per cent of green house gases added in the last 100 years (WRI, 2001). In terms of world carbon dioxide emissions for global warming, the contribution of Indian agriculture was 0.23 per cent (Bhatia.A.2004). It is felt that the unsustainable fossil fuel based consumption patterns of the rich industrialised nations are responsible for the threat of climate change. Only 25 per cent of the global population lives in these countries, but they emit more than 70 per cent of the total global carbon dioxide emissions and consume 75 to 80 per cent of many of the other resources of the world (Parikh *et. al.* 1991). Though our country stands in top five countries in terms of green house gas emissions, the difference between first and other countries in terms of total volume of emissions is very large. For example, in the year 2005, the total CO_2 emissions from India were 1.1 BT and the same from China was 4.7 BT and USA was 5.9 BT (The Guardian). Pathak *et.al*. (2002) emphasised the need for an equitable and efficient solution to climate change and suggest that efficiency can be obtained through a system of tradable emission quotas and equity through equal allocation of global environmental space to all human beings.

Another theme of Indian analysts has been the lack of reliability of GHG emission estimates particularly of methane. According to initial estimates, large emissions of methane from paddy fields were ascribed to developing countries. However, the empirical basis of these estimates was questioned subsequently. Experimental measurements by Indian researchers showed these doubts to be well founded (Mitra 1996). ICAR estimates show that methane and nitrous oxide from Indian agricultural soils are responsible for only about 0.23 and 0.1 per cent, respectively (Bhatia *et.al.* 2004).

Impact of Climate Change on Agriculture

Given that rain-dependent agricultural area constitutes about 60 per cent of the net sown area of 142 mha (TERI 2003), Indian agriculture continues to be fundamentally dependent on the weather, with much of the recent high growth rates being the result of a number of successive good monsoons.

Indian climate is dominated by the south-west monsoon, which brings most of the region's precipitation. It is critical for the availability of drinking water and irrigation for agriculture. Agricultural productivity is sensitive to the following classes of climate-induced effects :

* Effect of increasing temperature on crops.
* Direct effect of increasing levels of CO_2 on crops.

Effect of Temperature : The change of weather with respect to temperature in different seasons is very characteristic in India. One of the major green house effects would be an increase in global mean temperature ranging from 1.5 to 4.5 ^{0}C. At present it is not clear as to how this global mean temperature would be distributed in different regions of the world. However, it is predicted that there could be serious effects on the productivity of many crops.

Cereals are the major foodgrains for consumption in our country. Since

Independence the proportion of wheat and rice in total cereal production has shown a remarkable change. In 1951-52 the proportion of wheat and rice was 55 per cent and coarse grains accounted for 45 per cent. The proportion has changed to 85 and 15 per cent in 2009-10. An important implication of this change is that our dependence on rice and wheat has increased considerably. Any factor which would influence the productivity of these crops would affect our food security. Both these crops are sensitive to higher temperature as discussed by Sinha *et. al.* (1989) and Sinha and Swaminathan (1990).The rice yields are strongly influenced by temperature regimes which have been brought out through the International Rice Testing Programme organised by the International Rice Research Institute. Increasing mean daily temperature results in decreasing the period from transplantation to maturity but is also accompanied by decreasing crop yield.

Results of the process simulation models of IARI show that a 1^0C increase in temperature may reduce the yields of wheat, soyabean, mustard, groundnut and potato by 3-7 per cent (Agarwal 2004). There are several reasons for this variation in response to one degree change in temperature regimes. Any increase in temperature even of the order of 1 to 2^0C, would result in adversely influencing the productivity of crops. Seshu and Cady (1984) estimated a yield decrease of 0.71 t/ha with an increase of minimum temperature from 18 to 19^0 C, a decrease of 0.41 t/ha from 22 to 23^0 C and 0.04 t/ha from 27 to 28 ^{0}C respectively in rice crop. Similarly, it is estimated by them that with a 0.5 ^{0}C increase in temperature there would be reduction in wheat crop duration by 7 days, which in turn would reduce yield by 0.45 t/ha.

Effect of Carbondioxide : Changes in the use of land affect the amount of carbon stored in vegetation and soils and hence affect the flux of carbon between the land and atmosphere. Forests, for example contain the order of 20 to 100 times more carbon per unit area than croplands. The transformation of forests to croplands reduces the storage of carbon on land and releases the carbon to the atmosphere. The accelerating trend of late, is reduction in the area of forests and increase in the area of agricultural lands and therefore, an accelerating release of carbon to the atmosphere. Several experiments in the past have shown that increasing levels of carbondioxide could increase photosynthesis rate and hence dry matter production and productivity of C3 plants in arid regions of India but it appears that the increase in temperature may offset the beneficial effects of CO_2 (Chattopadhyay).

Rainfed Farming : Some Issues

A large part of the India's sub-continent is prone to droughts which is evident from frequent recurrence of severe droughts in one-third of India's geographical area. The fragile ecosystems of the drylands with their delicate ecological equilibrium and reduced water supply are very vulnerable to the stresses of climatic fluctuations. There are large variations in the total rainfall from place to place in the country and from year to year. These variations are particularly large in drought-prone areas where the rainfall is 20-40 cm or less. And this precipitation occurs in mere 20-30 hrs at any place. Moreover, an overwhelmingly large part (>85 per cent) of this water goes waste as floods and less than 15 per cent infiltrates underground to recharge the groundwater (Valdiya 1987). Even if there is a normal rainfall in any region as a whole, there is always a considerable uneven distribution and erratic precipitation. Not surprisingly 260 million ha or 79 per cent of the total geographical area of India is subjected to drought experiencing less than 75 per cent of the normal rainfall and acute scarcity of moisture in the soil. Successive droughts have caused lowering of water table and general desiccation of ground in many parts of the country. This has accelerated the pace of desertification. Computer models predict that the intensity of droughts and the frequency of mid latitude heat waves and of severe cyclonic storms will increase. The intensity and timing of monsoons may be altered quite likely causing difficulties with agriculture regardless of the direction of change.

The possible implications therefore, are decrease in the yield of cereal based crop production system in irrigated agriculture as a result of increase in temperature and carbondioxide and decrease in gross sown area under drylands as a result of variation in rainfall distribution and intensity. As the productivity of irrigated agriculture has reached a plateau because of adoption of unsustained chemical agriculture technology, the country has to depend on rainfed regions for its future economy and food security. The present agriculture situation and food crises warrant the need for second and ever green revolution that has to come from rainfed region. However, in the present context, maintaining the foodgrain production in pace with the increasing population is a real challenge. The scope for horizontal expansion of agriculture is almost nil as agriculture in India has already extended to marginal lands. Therefore, only vertical expansion with sustainable and eco-friendly agricultural practices is the option left to make the production viable and to meet the food security in long run.

Policies and Practices for Rainfed Farming in the Light of Climate Change

The area under rainfed agriculture is going to expand because of the impact of climate change. Agriculture in rainfed areas differs from that of irrigated systems in capital base to crop productivity. It is the dominant source of employment, income and sustenance for the bulk of the population in the country. Its contribution to national income and employment is around 70 to 80 per cent supporting 44 per cent of our total foodgrain requirement in terms of cereals (50 per cent), pulses (86 per cent), oilseeds (80 per cent) etc. (Singh 2002). Hence, any climatic change which adversely affects the resource base and production environment of rainfed agriculture would severely affect the economic and social impacts.

In the context of nation's food security, the focus should be to enhance the productivity of rainfed agriculture by restructuring the agricultural policy that is appropriate and exclusive to rainfed farming and also differs with that of irrigated farming systems. Enabling a policy that strengthens the natural resources and avoiding the exploitation of resources is the prerequisite for rainfed regions. The policy measures should narrow the gap between potential yield and actual yield with in-built adaptations to climate change. Through a variety of practices aimed at diversification and sustainability, the farmers in the rainfed regions have developed adjustment mechanisms against climatic risks (Jodha *et. al.* 1987). These adjustment strategies are sources of resilience of the system which can offer some clues for adaptation approaches against global warming induced climate risks. In addition, the strategies to be adopted are perceived in the context of rural development in order to deliberate upon some convergence in programmes and funds.

The following are the major areas that need policy advocacy.

Land Development : The present concept of land development in all the rural development programmes orbits around soil and moisture conservation practices. Simple soil conservation practices/structures may protect the land from further degradation but do not address the productivity of lands that were already degraded. The concept of productivity should be seen in the broader context of land rather than crops which includes management of crop, water and soil fertility. It is also revealed in many studies that continuous application of chemical fertilisers over long period results in soil degradation. Moreover, subsidy to selected nutrients resulted in imbalance of nutrients in soil thus impairing the complete nutrient availability to plants which results in deficiency of several micronutrients. Hence, application of subsidy based chemical fertilisers alone is not a viable option for productivity improvement in rainfed areas. Input subsidies should be such that they must result in internalising the production system and should make the farmer less dependent on external inputs and should make the production environmentally safe and cost-effective.

Groundwater Management : Rainfed agriculture has become more vulnerable because of rainfall variances recurring as a result of climate change. The irony is that, many a time the kharif crop which is the only crop on which rainfed farmers can be dependable is in jeopardy due to rainfall fluctuations. A minimum of 1-2 irrigations should be provided during critical stages of crop growth to sustain the crop as well as to increase the yield substantially. The implied value of capital cost of surface irrigation was worked out to be ₹ 70,000 per ha (Dhawan 1997) . Whereas, there is no policy to support investments on critical or protective irrigations in rainfed areas. The present practice of digging of borewells without any control have resulted in competitive digging by the farmers which has led to exploitation of groundwater. Though legislations have come up to prevent this such as APWALTA in Andhra Pradesh, the enforcement is not stringent due to judiciary and other lacunae. The power politics on free power to attract the farmers further aggravated the crisis of groundwater exploitation.

Institutions are already in place in some States such as Andhra Pradesh and Tamil Nadu in the form of water user groups for sharing the surface irrigation and for taking the responsibility of maintenance of the surface irrigation projects. Similar institutions must be promoted in rainfed areas for the sharing of groundwater where the State should take a lead in providing groundwater, by digging borewells, by pooling the borewells, by imposing social regulations that restrict the competitive digging of borewells and for sharing the groundwater. Lessons can be drawn from Zimbabwe Water Act which envisages water (Ground and surface water) as state property which is to be managed by catchment councils at unit level and time-bound water permits to be issued by catchment councils as against water rights held in perpetuity in our country.

Support Systems for Rainfed Farming : Another major concern is the timely availability of seeds including contingency seeds, seedlings for planting bunds etc. as timely sowing reduces the risk of pest incidence by 30 per cent. However, the present policy does not recognise the seed banks and hence, most of the subsidy given for the seeds by the government is being appropriated in other routes. Seed systems within the village under the control of community in the form of community managed seed banks could solve the problems of timely availability of seed. Contingency crop seeds and seeds of inter-crops should also be made available at seed banks. The seed banks run by many voluntary organisations are already in place. The experiences of these organisations could be considered for institutionalisation of the seed bank programme through farmers' groups or through SHGs. This also can be placed or visioned under the National Livelihood Mission of MoRD. This system can result in crop diversification through inter-cropping with food and fodder crops and also in promoting green manuring. Policy advocacy would be needed to consider the seed bank for interventions on seed distribution, distribution of contingency seed during the drought.

Cultivation Practices : The System of Rice Intensification (SRI) is being promoted to improve water use efficiency in paddy. This method also reduces methane gas emissions which is a major culprit being highlighted in case of water-logged paddy cultivation. The SRI advocates drainage of soil which not only aerates the soil but also the drying stimulates rice root development and also accelerates decomposition of organic manure in the soil organically which reduces methane emission. The concern of the farmers with this system is it promotes weeding. Therefore, popularising the SRI with incentivising the weeding machinery may be promoted.

Extension System : Studies reveal that extension system under public-private partnership involving NGOs gives good results in dissemination of technology. Extension and technology support by the government was more towards large and medium farmers whereas, the NGO's support was more for small and marginal farmers (Radhika *et.al.* 2006). Therefore, the involvement of CBOs, SHGs, farmer groups, CIGs, paravets, village activists etc. should be institutionalised in extension system to act as a window for alternate delivery system for technology transfer, supply of inputs, awareness programmes and communication campaigning etc.

Conserving the Genetic Material : Rainfed region is endowed with wide biodiversity that withstands harsh climate. However, proper policy is not in place to conserve it. The bio-diversity management committees as visioned in the National Bio Diversity Act were not in place in many panchayats. Many livestock breeds and crops native to rainfed regions are replaced by the new breeds which failed to adjust to the harsh climate. For example, drought resistant Deccani sheep breed in Deccani track and local poultry breed are replaced by the improved breeds. Similarly, millets of rainfed crops are replaced by irrigated dry crops and irrigated crops. Developing drought-resistant varieties by using the local strains of rainfed crops need to be promoted.

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