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Rapporteur's Report on Climate Change – Its Impact on Agriculture Productivity and Livelihood: The Policy Response

Rapporteur: S. Suryaprakash*

Ten broad areas were suggested for the paper writers. The 41 papers received and accepted have mostly addressed the impact of climate change on crop production. Again, the studies mostly covered the impact of rainfall variability and temperature increase on crop production. The papers were reviewed and the report is presented under the broad areas of influence of climate change.

CLIMATE CHANGE AND CROP PRODUCTION

Thirteen papers addressed the issue of climate change effect on crop production, based mostly on secondary data. But few studies did the analysis through primary data.

Rikhi R. Kondal *et al.* attempted to quantify the impact of climate change on the agricultural productivity of Himachal Pradesh. Based on the selected indicators, experiments evidence and inferences drawn from the studies of Himachal Agricultural University, the authors abstracted the impact of climate change in terms of rise in air temperature, variation in rainfall patterns, changes in duration of crop maturity and other undesirable effects of climate change in Himachal Pradesh. Citing the secondary sources they report that temperature has risen from by 0.7 to 2.4⁰ c during the period of 30 years. Based on this temperature rise, they try to analyse productivity changes in rice, wheat, maize and apples. The variation in the productivity of wheat, rice, maize and apples was directly attributed to rise in temperature without any cause and effect analysis and neglecting the influence of other important variables. A.R. Verma deals only with production costs and marketing of onions, without any reference to the impact of climate change on onion production.

S.S. Kalamkar's paper deals explicitly with the impact of climate change on agriculture in the country based on the secondary data from different sources. Quoting various sources and publications, the author traces the history of climate change and its ramifications on human society. Quoting the source of IPCC, he describes four different scenarios that explain the effect of climate change on variation on grain production changes across developed countries and developing countries. Though, the overall global impact of climate change on agricultural

*Dean (Post-graduate Studies), University of Agricultural Sciences, Bangalore - 560 065.

production may be small, regional vulnerabilities of food dimension may increase due to various reasons. He touches upon the international efforts and negotiations to combat green house gases emissions (GHGs) through some land mark negotiations such as UNFCCC, Kyoto Protocol, IPCC, etc. He devotes substantial space for recording the negative impact of climate change on Indian agriculture including floods, more droughts, disease spread, etc. as climate change will have more effect on the northern parts of the country with the exception of Punjab, Rajasthan and Tamil Nadu. A detailed account of the impact assessment of climate change has been presented drawing inferences from various published literature on the subject. The focus is on how climate change will affect the stages of crop growth such as stages at which crop yield is affected, increased incidence of pests and diseases, new equilibrium between crops and pests, which result in heightened mineralisation process and decrease in fertiliser use efficiency.

The paper by B.S. Naregal describes the manner in which climate change will affect agricultural productivity and livelihoods of rural communities in the country and policy response towards climate change. The study is mainly based on the secondary data from various sources. The paper vividly describes the manner in which rise in temperature could affect growth of crop plants, flowering pattern, fruit setting, declining soil fertility, decline in water table, pollution levels and other associated negative externalities of climate change. Based on the IPCC publication, he reports that food production in the country is likely to fall by 4 to 5 tonnes in the case of wheat for every one per cent rise in temperature. The author lists the potential negative impacts on agriculture in India. Simulation models show that wheat production is going to fall such that the wheat output by 2070 could be only 59 mt whereas the population would be much more. Various national programmes are listed that deal with efforts to minimise the negative impacts of climate change. Quoting secondary sources, the author delves into the aspects of livelihood changes due to climate change.

V.T. Raju's paper on climate change and Indian agriculture which is based on the secondary data and published literature largely deals with macro level impact of climate change on Indian agriculture with special focus on agronomic and economic impacts. Rice yields are likely to decline by 5 to 12 per cent in India and China. With a further rise in temperature, the overall rice production in Asia could fall by just under 4 per cent by the end of the present century. Under economic impact he tries to draw inferences based on two basic methods which many studies have used. The first one is the agronomic and economic approach and the second one is spatial analogue approach. Further he indicates that due to climate change the food production is going to be reduced considerably by 2020. The gross domestic product (GDP) could also decline by 1.4 to 3 per cent under various climate change scenarios with adverse poverty effects.

Swami Prakash Srivastava has reviewed various studies and has elaborated on the relationship between percentage of departure and agriculture growth. The impact of

climate change on Indian agriculture in terms of crop yields and crop yields in the light of increased CO₂ is discussed. The effect of climate change in India show differential impact in crop response in different states. The warming is more pronounced over land areas compared to sea, with the maximum increase over northern India, and during winter rather than summer. According to the study, it is projected that by the end of the 21st century, rainfall will increase by 15-31 per cent and the mean annual temperature will increase by 3-6°C. The author has discussed climate change and food security, IPRs, biodiversity, trans-boundary pests, melting glaciers and snow fall in Himalayas.

The paper of Brajesh Jha and Amarnath Tripathi examines the impact of changes in winter season temperatures and winter rainfall on wheat yield in Haryana and Bihar using actual field data drawn from secondary sources. The wheat yield was regressed on positive deviation in maximum temperature, square of positive deviation of temperature and also on the time trend for the period from 1980 to 2003. The study shows that increase in maximum temperature from the long run average had negative effect on wheat yields. The analysis shows that increase in temperature from long run average (1961-1990) initially affects yield positively, subsequent increase in temperature affects yield of wheat adversely. These results conform to some extent with the simulation based studies. The changing pattern of rainfall during winter season was found to influence wheat yield in the recent periods. The authors suggest that though farmers are adopting certain agricultural practices, there is a need for developing suitable varieties that are more tolerant to extreme temperatures.

Shalander Kumar and others have assessed the sensitivity of yields of major rainfed crops to climate change in India using yield data of bajra, jowar and maize crops from 1990 to 2008 and data on climatic variables like district-wise monthly maximum temperature during *kharif* season, wet day frequency and total precipitation through multiple linear regression. The effect of technological progress on yields was removed through detrending of the data. The results show that increase in rainfall and number of rainy days would result in yield increment in most districts and vice versa. The *kharif* maximum temperature was found to influence rainfed crop yields negatively in most districts.

K.V. Asha Latha and Munisamy Gopinath have studied the impact of climate change on Karnataka's agriculture by spatial techniques. They indicate that stochastic frontier analysis gives better results in analysing the effects of temperature and rainfall as their influence can be considerable even over distances of a few kilometers. They conclude that the spatial effect of annual rainfall induces higher production, whereas spatial dependence of average temperature has inverse relation on production. Climate change is likely to impose significant cost on the economy unless coping mechanisms are not adopted for increasing temperatures. M.S. Pathania and J.S. Guleria have analysed the climate change effects in Himachal Pradesh using published data. Decreasing precipitation, high variability in rainfall and significant decrease in snow fall were observed over years. Rainfall was found to

significantly influence crop productivity. Farmers' perceptions of climate change were compiled from a sample of 80 farmers. They indicated that climate change resulted in increase in summer temperatures, unpredictable rainfall, prolonged summers, delayed onset of winter, decrease in snowfall and delayed onset of South West monsoon.

The economic analysis of impact of climate change on select crops in Tamil Nadu was attempted by J.S. Amarnath *et al.* Using multiple regression analysis, the influence of minimum and maximum temperatures, rainfall and area under the crop on the production of sorghum, bajra and ground crops was assessed taking time series data for the period from 1988-89 to 2007-08. The area under the crop, maximum and minimum temperatures were found to significantly influence productivity of these crops. However, the climate variables were not found to influence maize, cotton and sugarcane crops.

Aravind Kammar *et al.* assessed the impact of climate change on major crops in Karnataka using secondary data from 1979-80 to 2007-08. The impact of actual rainfall and deviation from normal rainfall on crop yields was estimated through multiple linear regression. The actual rainfall affected yields of rice, wheat, maize, ragi, gram, small millets and cotton. The percent deviation from normal rainfall had negative impact on yield of all major crops except jowar, groundnut, sunflower and sugarcane. Advance dissemination of weather information may guide the farmers to adopt suitable coping mechanisms to mitigate the loss in crop yields. N. Saraswathy and T. Selvakumar, using secondary data, indicated that rainfall influences growth in agriculture sector which in turn has a bearing on the overall GDP growth. They suggested efforts to mitigate climate change effect on agriculture sector.

CLIMATE CHANGE, RAINFALL AND GROUND WATER

In all seven papers made an attempt on assessing the climate change through rainfall and the impact on irrigation and ground water.

Pradeep Hadke and Surendra Jichkar's paper is more of a summary of impact of climate change on agriculture in terms of variables or components which are more prone to climate change. This paper identifies the impact of climate change on water resources of the country especially on per capita availability under several criteria. Further, commenting on the climate change and human health, they deplore that climate change could lead to heart-related deaths and illness and deaths due to cold weather conditions could decrease as a result of global warming. Deepa B. Hiremath and R.L. Shiyani attempt to characterise the rainfall pattern through the analysis of variation in rainfall in Gujarat state although they do not explicitly address climate change and its impact. Taking the route of agro-climatic description, they tried to reason out climatic variability. The analysis is quite rigorous in which rainfall deviations were classified by class intervals of 10 per cent deviation from mean rainfall and surplus/deficit rainfall was computed across the selected districts. They

identified the driest and wettest years during the reference period 1978-2008. The authors conclude that the northwest arid zone was the most vulnerable zone. They suggest that climate change prediction capability should be enhanced through link to hydrometeorological organisations and enhancing capacities of people and communities.

O.P. Singh *et al.* have attempted to assess the impact of climate change on Indian agriculture. Data related to area, production and productivity of principal crops is collected over time. Water requirement for all major crops of agro-climatic sub-zones was estimated using "Crop Wat" database of FAO. The water requirement was measured using the concept of Evapo-transpiration. The water demand for different scenarios is calculated. In addition, the needs of crops was assessed. Foodgrains needs 69.16 per cent, oilseeds 11.87 per cent and pulses 3.90 per cent of water. Among food grains paddy (69.30 per cent) and wheat (15.2 per cent) account for major requirement. They estimated that increase in temperature by 1, 2, 3 °C from the present level would reduce grain output substantially. This may also bring about crop shifts for coping.

The impact of climate change and cropping pattern on ground water resources in Punjab was assessed by Baljinder Kaur. It is shown that due to increase in the proportion of area under the two water intensive crops of paddy (27.93 per cent to 62.09 per cent of total cultivated area) and wheat (34.40 per cent to 82.14 per cent), the demand for water has increased from 1.49 million ha meter in 1970-71 to 6.15 million ha meter in 2004.05. This has led to increased draft of ground water and the resultant fall in ground water table. Linear programming model was employed to arrive at optimum cropping pattern for maximising net returns and ensuring significant saving of ground water using the cost of cultivation of principal crops scheme data. Postponing date of paddy transplanting, increased area under cotton were some of the suggestions for saving water use without any adverse impact on profitability.

Rajinder Sidhu *et al.* emphasise the presence of impact of climate change on water resources (dwindling ground water resources), on power usage and power subsidies (increased use of energy in agriculture and adverse effect on the budgetary allocations due to increased cost of subsidising power use in agriculture) on crop yields (rising winter temperatures affecting wheat yield from 4.7 tonnes/ha in 1999-2000 to 4.1 tonnes/ha in 2005-06) and on cost of production and income (increased expenditure on diesel use for irrigating rice, increased cost of well deepening, pump replacement). H.S. Ranaware studied the ground water condition in Malshiras tehsil of Maharashtra using data compiled from 30 tubewell farmers. He observed that none of the tubewell farmers recharged ground water. Industrial waste and municipal waste water have polluted ground water. The level of ground water has not reduced due to less abstraction owing to long periods of load shedding.

U.H. Kumar and S.S.P. Sharma examined the effectiveness of land and water use practices of small and marginal farmers to the emerging scenario of climate change in

Gujarat, Tamil Nadu, Jharkhand and West Bengal states based on both secondary and primary data. They suggest that land and water use policies should be in tune with climate change. A. Narayanamoorthy studied the climate change impacts on ground water extraction in Pudukkottai district of Tamil Nadu. He concludes that climate change is going to reduce the availability of groundwater as it is capable of increasing the variability in rainfall and reduced number of rainy days. This would deplete the ground water level and increase the water extraction cost. This will increase the vulnerability of resource poor farmers in the future. Some supply and demand management strategies are suggested to tackle climate change induced exploitation of groundwater.

CLIMATE CHANGE AND LIVESTOCK SECTOR

Hardly three papers addressed this issue. Babu Singh *et al.* have explained the role of livestock in agriculture GDP growth, the contribution of milk, meat, poultry and the growth of livestock wealth in India and Uttar Pradesh. However, the study fails to bring out any clear relation between climate change and livestock. Sumit Mahajan *et al.* indicate that climate change will affect livestock productivity due to increased heat stress, feed and fodder shortages and reducing biodiversity. Adoption of mitigation strategies is imperative given the fact that most of the livestock owners are small holder farmers who maintain livestock for livelihood and these strategies should be region-specific. Some of the measures suggested are shelter modification to reduce solar radiation; nutritional management including rational feed adjustments and feeding management; and reorienting breeding policy to maintain adaptive traits. Prem Chand *et al.* estimated the enteric methane from dairy animals in the semi arid region of Rajasthan. Enteric methane emission accounts for 17 per cent of national green house gas emissions and it is a major source from agriculture. Reducing enteric methane emissions also improves the rumen fermentation efficiency of ruminants. Methane emission factors were found low for dry dairy animals more for the indigenous animals.

CLIMATE CHANGE AND FISHERY SECTOR

The only paper in this section by G.P. Reddy *et al.* observes that aquaculture, due to growing demand for its products, has led to fast depletion and degradation of natural resources and environmental damages. This calls for judicious use of resources for sustainable aquaculture. The authors suggest stake holder involvement in the research and planning process through a frame work of participatory geo-spatial information system.

CLIMATE CHANGE, LIVELIHOOD FOOD SECURITY AND SUSTAINABILITY

Six papers address this albeit partially. One common feature of most of the papers is that the discussion on impact of climate change is almost identical because these authors deal more or less similar research papers and source material like, IPCC, UNFCCC and others. But the paper by D. Tata Rao deviates from this common thread and deals with more on food security and high energy prices as influenced by climate change. Again like other authors, he also draws inferences from IPCC, FAO and UNFCCC. A brief account of GHG emissions from agriculture was dealt with and nitrous oxide is the major emission from agriculture. He highlighted impact of climate change on food security and high energy prices.

The paper by B.S. Naregal describes the manner in which climate change will affect agricultural productivity and livelihoods of rural communities in the country and policy response towards climate change. The study is mainly based on the secondary data from various sources. The paper vividly describes the manner in which rise in temperature could affect growth of crop plants, flowering pattern, fruit setting, declining soil fertility, decline in water table, pollution levels and other associated negative externalities of climate change. Based on the IPCC publication, he reports that food production in the country is likely to fall by 4 to 5 tonnes in the case of wheat for every one per cent rise in temperature. The author lists potential negative impacts on agriculture in India. Simulation models show that wheat production is going to fall such that the wheat output by 2070 could be only 59 mt whereas the population would be much more. The author lists various national programmes that deal with efforts to minimise the negative impacts of climate change. Quoting secondary sources, the author delves into the aspects of livelihood changes due to climate change. The author calls for assisting the vulnerable communities to empower them to build their livelihoods and cope with climatic uncertainties in the long run.

The research paper by Ram Singh *et al.* tries to document the perceptions of farmers about the impact of climate change on rural livelihoods in Meghalaya through two focus groups in each village comprising men and women. They report that farmers had awareness about climate change as they could easily identify changes that had taken place over the years as they felt that the quantum of rainfall was more earlier than now. Majority of the farmers felt that the temperature was rising alarmingly, livestock diseases increased, and loss in milk yield were reported. The authors suggest various mitigation strategies including adaption of farmers to changing scenarios to support their livelihoods with diverse activities.

CLIMATE CHANGE AND POLICY RESPONSE

Only two papers make an attempt at indicating the policy response needed for addressing the issue of climate change. B.S. Naregal lists various national programmes that deal with efforts to minimise the negative impacts of climate

change. Quoting secondary sources, the author delves into the aspects of livelihood changes due to climate change. The author calls for assisting the vulnerable communities to empower them to build their livelihoods and cope with climatic uncertainties in the long run. O.P. Singh *et al*, while attempting to assess the impact of climate change on Indian agriculture suggested for improvement irrigation efficiency, change cropping pattern, develop drought and heat tolerant varieties, resource conservation, CO₂ sequestration.

CLIMATE CHANGE: STAKE HOLDER PERCEPTIONS AND MITIGATION MEASURES

Eleven papers addressed this issue while studying the impact of climate change on different sub-sectors of agriculture.

S.S. Kalamkar suggested increased adaptation and mitigation research, capacity building changes in policies, regional cooperation, and support of global adaptation and mitigation funds and other resources. In the area of crop production, he suggests, development of climate tolerant genotypes, and land and water use systems and assisting farmers in coping with current climatic risks through providing weather linked value-added advisory services and crop/weather insurance. Pradeep Hadke and Surendra Jichkar suggest several measures for mitigating climate change such as encouraging sustainable agriculture, reorienting forest policy to increase the augmenting the capacity and area under forest in the country, identification of priorities of the health sector, and related measures. Ram Singh *et al*. tries to document the perceptions of farmers about the impact of climate change on rural livelihoods in Meghalaya through two focus groups comprising men and women. They report that farmers had awareness about climate change as they could easily identify changes that had taken place over the years as they felt that the quantum of rainfall was more earlier than now. Majority of the farmers felt that the temperature was rising alarmingly, livestock diseases increased, and loss in milk yield were reported. They suggest various mitigation strategies including adaption of farmers to changing scenarios to support their livelihoods with diverse activities.

S.K. Gupta suggests crops, varieties and production practices to be adopted under situations of late onset of monsoon, very late onset of monsoon, early withdrawal of monsoon and dry spell during crop growth period. But the author does not bring out any economic issue in this regard. Rajinder Sidhu *et al*. suggested different strategies to address climate change impacts including climate forecasting through development of integrated regional weather-climate forecast system, projected climate changes from the IPCC models for the region; formulation of alternate policies for energy subsidy and water saving by way of metering and marginal cost pricing of power, direct cash subsidy for electricity; water-energy saving technological choices including diffusion and adopting of physical and financially viable technologies and practices to save water and energy without affecting crop yields and incomes;

developing agriculture supply chains especially for price volatile high value products such as fruits and vegetables; and use of ICT tools.

M.S. Pathania and J.S. Guleria indicate that farmers' perception about climate change was facilitated by factors like age, education, farming experience, consciousness to environment and exposure to multimedia. The mitigation strategies adopted were use of water conservation techniques, intercropping and soil conservation practices. S. Angles *et al.* assessed the perception of dryland farmers on climate change and the coping mechanisms to mitigate the same in Dharmapuri district of Tamil Nadu. The authors collected primary data from 90 respondents for the study. The authors, using crop yield data from 1990-91 to 2008-09, showed that the study district experienced greater instability in major rianfed crop yields. The yield loss varied between 11 and 60 per cent for various crops from normal yield due to drought. Most of the sample farmers were not able to express their perception on climate change directly but they expressed through the effects or changes occurred compared to the earlier years. Reduction in income, erratic rainfall, change in rainfall pattern, crop failure, reduction in yield, pest and disease outbreak and fast evaporation of soil moisture were the major impact of climate change. Rainfall and pests and diseases were perceived to be the major reasons for yield reduction. The major coping mechanisms adopted by the dryland farmers to mitigate climate change effects were adoption of mixed/inter cropping pattern and integrated/mixed farming systems and change in cropping pattern. Nearly half the respondents have shifted to other professions, while 49 per cent had increased their borrowing. Crop insurance has not been followed by majority of the respondents. The results of the logit model revealed that education, income, experience, membership in farmers associations, size of holding and risk taking character were the factors significantly contributing to adoption of coping mechanisms.

U.H. Kumar and S.S.P. Sharma opine that watershed is an excellent exercise of micro-environment for putting together all practices into area development of improved biomass, efficient water use and internalised production systems. R. Jaya Kumaravaradan *et al.* have analysed the performance of National Agricultural Insurance Scheme (NAIS) as an adaptation measure to overcome the adverse impact of climate change on agriculture in Tamil Nadu using a sample of 180 farmers. The authors identified that credit accessibility, opinion of fellow farmers, education and farming experience have positive influence on adoption of crop insurance. Crop insurance was found to serve as a substitute for crop diversification. K.N.S. Banafar and M.R. Chandrakar conducted a micro level study to assess the farmers' perception about regional climate change on pigeon pea production. The study revealed that increased temperature causes severity of insect pests and diseases, high intensity of rainfall causes flower dropping and high relative humidity favours insect attack. Prem Chand *et al.* suggest that incorporation of energy efficient diets like concentrates and by-products of sugar industry, maintaining livestock population in relation to carrying

capacity, improving the productivity were the options suggested for reducing enteric methane emissions from livestock.

RESEARCH ISSUES FOR DISCUSSION

Most of the papers have based their findings on secondary data and dwell on the issues that are fairly well addressed in the international fora. Primary data based studies are few and far between. Again, the papers hardly dwell on economic issues. It is not difficult to comprehend that for making a serious attempt at addressing the issues related to climate change, multi-disciplinary research is called for.

The impact of climate change on fishery and forest sectors is substantial but this has not drawn the attention of paper writers. The need for policy response called for mitigating the adverse impacts of climate change is not addressed. It is very important to study the resilience measures adopted by individuals and communities to reduce the losses brought about by climate change, need and efforts at increasing social action at increasing resilience.

The analysis of the policy responses initiated and their impacts – social, economic and equity, need and justification for refining the existing programmes and policies, need and scope for involvement of non-governmental agencies and stake holders in devising policies and programmes addressed to mitigate the effects of climate change is a crucial issue that need the attention of social science researchers. The economists can clearly bring out the associated economic issues.