Ind. Jn. of Agri. Econ.
Vol.66, No.3, July-Sept. 2011

Climate Change and Agricultural Productivity: A Study of Himachal Pradesh

Rikhi R. Kondal*, Shiv Dyal Sharma and Bihari Lal*****

There is a great variation in the climatic conditions of the state of Himachal Pradesh due to variations in altitudes. The state comprises hilly terrain, perennial rivers and significant forest cover. The economy of Himachal Pradesh is dependent on the agricultural sector and any climatic fluctuation causes some changes in economic growth because this sector has an overall impact on the other sectors, viz., input linkages, employment, trade etc. The state is divided into nine agro-ecological zones (AEZ). The use of the AEZ can form a useful base for agricultural planning and sustainable natural resources management. The present analysis is based on the data from the period 1993-94 to 2007-08. The analysis reveals that weather vagaries affect the productivity. Because of climatic variations the movement of apple orchards are observed to the higher altitudes. The study further reveals that weather is an important basic input of the agricultural production system. The impact of the climate change on productivity is different in different crops as these crops need different weather elements. Therefore it causes different percentage variation on productivity in different crops during a season whereas climate change over the period of time causes variation in the productivity of a crop from season to season and it affects the livelihood of the people.

Climate Change Impact on Onion Production and Marketing in Indore District of Madhya Pradesh

A.R. Verma†

The paper makes an attempt to analyse the effects of climate change on onion production and marketing in Indore district of Madhya Pradesh. It examines the cost and returns, the net return, cost of production per quintal of onion, input-output ratio in the production of onion on small, medium and large size-groups of farms and estimates the various marketing costs and margins and the onion grower's share in the consumer's rupee, marketing efficiency of onion and the problems faced by the onion growers in the marketing of onion in Indore district in Madhya Pradesh and

*Associate Professor, Department of Economics, Government Post College, Bilaspur (Himachal Pradesh), Associate Professor, Department of Economics, Government Post College Chamba (Himachal Pradesh) and Assistant Professor, Department of Economics, Government College Bursar, Hamirpur (Himachal Pradesh), respectively.

†Professor, Department of Agricultural Economics, Madhya Pradesh Pashu Chkitsa Vigyan Vishwa Vidyalaya, Campus College of Veterinary Science and Animal Husbandry, Mhow, District Indore (Madhya Pradesh).

sale in the vegetable mandi of Indore city. Multi-stage stratified random sampling method was used for the selection of six villages and onion producers from Indore block of the study district. The farmers were stratified into three groups viz., small (less 2 hectares), medium (2-4 hectares) and large (4 hectares and above) farms. The primary data were collected from 60 farmers. Ten wholesalers/commission agents and ten retailers were selected randomly from the regulated market prevalent in Indore "vegetable mandi" where maximum quantity of onion is sold by the producers. The actual marketing costs incurred by the sample onion producers through different channels were considered. The marketing channels identified for the study are Channel-I: Producer-Consumer, Channel-II: Producer-Retailer-Consumer and Channel-III: Producer-Wholesaler-Retailer-Consumer. The primary data regarding cost of cultivation, marketing costs and margins and constraints of marketing and functionaries collected pertained to the year 2009-10. The cost of cultivation per hectare of onion showed an increasing trend with the increase in the size of farms. The average yield and gross returns per hectare increased with the increase in the size of farms, because the large sized farmers had incurred higher investment per hectare on modern inputs in the production of onion which in turn resulted into higher yield and gross returns on these farms. The study revealed that the onion growers in the study area sold their produce through three marketing channels, viz., Channel-I: Producer-Consumer, Channel-II: Producer-Retailer-Consumer and Channel-III: Producer-Wholesaler-Retailer-Consumer. The marketing cost was the highest in channel III, followed by channel II and I. High cost of marketing and transportation are some of the problems faced by the farmers in the study area. The results of the study indicate that to reduce the price spread, the onion growers should be encouraged to sell their produce through co-operative marketing societies. Further, greater attention may be given to reduce the marketing cost and margin to intermediaries by taking several measures in channel-I, II and III because the cost of the produce passed through these channels of marketing. The analysis indicates that adequate input facilities and timely supply of cheaper credit by the financing agencies to the producers, processors and traders would help in increasing the productivity as well as efficiency in the marketing of the produce. The study suggests the need to develop onion grower organisations in the region. In the initial stage these organisations may be formed through non-governmental organisations to avoid the negative feeling among the farmers about the functioning of government owned organisation. Government may support these organisations by providing technical, financial and incentives to strengthen them. These organisations will be helpful in providing inputs, finances, storage facilities, technical know-how, crop wise training and marketing of vegetables and may also plan developing processing units at the village level.

Climate Change and Its Impact on Agriculture in India

S.S. Kalamkar*

An attempt is made to review the impact of climate change on Indian agriculture. The study is based on secondary data collected from different sources. The threat of climate change is now considered as an established fact and talked as a global common problem. It is generally recognised that climate change has an impact on agriculture and food security across the globe as agriculture is highly sensitive to changes in climate. Agriculture is the main source of livelihood for more than half of the world's population, and constitutes the cornerstone of the economy of many developing countries. A large fraction of the world's food is grown as rainfed annual crops in the tropics, where the change in climate plays an important role in determining productivity. Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves are known to negatively affect agricultural production, and farmers' livelihood. The projected increase in these events will result in greater instability in food production and threaten livelihood security of poor people. Most of the studies conclude that in many instances, agriculture will be disadvantaged and some predict unequal impacts of global warming on agriculture across regions. Climate change, although a global phenomenon, will have serious implications for the poor in India, making them more vulnerable to food insecurity and hunger. It will have an overall negative impact on Indian agriculture, with varying seasonal and regional implications. Producing enough food for meeting the increasing demand against the background of reducing resources in the changing climate scenario, while also minimising further environmental degradation, is a challenging task. This would require increased adaptation and mitigation research, capacity building, changes in policies, regional co-operation, and support of global adaptation and mitigation funds and other resources. Simple adaptations such as change in planting dates and crop varieties could help in reducing impacts of climate change to some extent. Additional strategies for increasing our adaptive capacity include bridging yield gaps to augment production, development of adverse climate tolerant genotypes and land use systems, assisting farmers in coping with current climatic risks through providing weather linked value-added advisory services to farmers and crop/weather insurance, and improved land and water use management and policies.

*Gokhale Institute of Politics and Economics (Deemed University), Pune - 411 004 (Maharashtra).

Climate Change and Its Impact on Socio-Economy in India

Pradeep Hadke and Surendra Jichkar†

In developing countries like India, climate change is an additional burden because ecological and socioeconomic systems are already facing pressures from rapid population, industrialisation and economic development. In this context, the paper has provided a broad classification of the various natural and human causes contributing to effect of climate change and its implications on agriculture, water resources, health, economic growth and along the coastal states. The measures for mitigating climate change are suggested. A National Forestry Action Programme (NFAP) was formulated as a comprehensive strategic long-term plan. The objective of the NFAP is to bring 33 per cent of the area of the country under tree/forest cover via afforestation by 2012 (as compared to about 24 per cent in 2003) and to arrest deforestation. The National Action Plan on Climate Change 2008 plan outlines the existing and future policies and programs for addressing climate change mitigation and adaptation, with a focus on eight "mission": (i) pursuing solar energy; (ii) urging energy efficiency; (iii) creating a sustainable habitat; (iv) conserving water; (v) preserving the Himalayan ecosystem; (vi) creating a "green" India; (vii) creating sustainable agriculture; and (viii) establishing a strategic knowledge platform for climate change. Through this modus operandi, the Action Plan seeks to put into action multi-pronged, long-term and integrated strategies for achieving key goals.

Global Climate Change: Its Impact on Agriculture

D. Tata Rao*

The paper reviews the effects of climate change on agriculture. The main interests are findings concerning the role of human adaptations in responding to climate change, possible regional impacts to agricultural systems and potential changes in patterns of food production and prices. The threats to climate change are more severe in developed countries, particularly due to undulating topography. By 2080, agricultural output in developing countries may decline by 20 per cent due to climate change, while output in industrial countries in expected to decrease by 6 per cent. Also due to climate change, yields in developing countries is expected to further decrease by 15 per cent on an average by 2080. The climate is a primary determinant of agricultural productivity. In turn, food and fiber production is essential for sustaining and enhancing human welfare. Hence, agriculture has been a major concern in the discussions on climate change. In fact, the United Nations Framework

†Associate Professor Department of Commerce, Dhanwate National College, Nagpur – 12 (Maharashtra).

*Teaching Associate, Department of Rural Development, Dr. B.R. Ambedkar University, Srikakulam, Etcherla – 532 410 (Andhra Pradesh).

Convention on Climate Change (UNFCCC) cites maintenance of our societal ability for food production in the face of climate change as one of the key motivations for its existence and for its efforts in stabilising greenhouse gas emissions.

Climate Change – Its Impact on Agricultural Productivity and Livelihood: The Policy Response

B.S. Naregal[†]

The paper intends to understand the conceptual clarity and issues of climate change and its impact on agricultural productivity and livelihood. It also examines the policy responses regarding climate change and its impact on agricultural productivity based on the findings of the study. The study is based mainly on secondary data and information. The study concludes that climate changes is one of the greatest threats to development and will remain so even in the near future. It is very difficult indeed to address the issue of climate change and its mitigation at farmers level. The farmers are merely a small contributor to the problem of environment changes owing to modernisation and urbanisation. However effective adaptation should be planned at macro level. The mitigation of climate can include utilisation of opportunities offered by conservation agriculture, use of biofuels, proper water and nutrient management of paddy fields, modification of the diet of ruminants. In the next few decades agriculture and allied activities will be influenced by climate changes. Though agriculture is technologically developed, its capacity to deliver food and contribute to the economic system is directly dependent on climate change. Therefore efforts are needed to define the strategies for adoption to climate changes particularly in agriculture sector through farm management and invest in the face of increasing uncertainty. For developing countries like India, adoption requires assisting the vulnerable population during unfavourable climate events and empowering them to build their lives and to cope with climate uncertainties in the long term. Efforts are being made by the Indian government to mainstream the climate impacts into sectoral policies. Climate change is perhaps the greatest challenges to sustainable development of all sectors of the economy including agriculture so it should be addressed by all countries with a shared perspective, free from narrow and myopic consideration. India's National Action Plans 2008 on climate change is in the process of implemention.

†Associate Professor, S.R.S.V. Arts and Commerce College, Shiggaon, Dist. Haveri – 581 205 (Karnataka).

Rainfall Variability in Gujarat: A Spatio-Temporal Analysis

Deepa B. Hiremath and R.L Shiyani*

The present study was undertaken to analyse the climatic data in terms of rainfall in order to classify and define the targeted regions, in order to understand what and how they varied and finally what is the impact of climate variability or change on agriculture. Annual rainfall data for the period from 1978-2008 were utilised in assessing the magnitude and extent of climate change for the 25 selected districts of Gujarat. These districts were selected as representating of various agro-climatic zones of Gujarat based on the availability of data. The results revealed that the Northwest arid zone was the most vulnerable zone among all the agro-climatic zones due to extreme deviations in rainfall pattern. This was followed by North Saurashtra, South Saurashtra and Middle Gujarat zones. The Southern hills zone had the least per cent of years with extreme deviations. The major suggestions which emerged from the study were that in the dryland areas like Kutch, there is a need for strategies unique to their system that takes into account their uncertain dynamics. Strategies such as rainwater harvesting, livestock development and techniques to enhance dryland agriculture can help overcome many of these constraints. Policies for promotion of efficient irrigation systems must be implemented. As a part of water management strategies there is a need to deepen wells, utilise water supply system properly, construct check-dams and focus on integrated watershed management and rainwater harvesting. Insurance coverage (crop, livestock *etc*) and microfinancing facilities may also be strengthened. Apart from this, while making investments particularly on dryland agriculture, a specific component of climate change could also prove useful.

Assessment of Effect of Climate Change on Rural Livelihood of Farmers in Meghalaya through Focus Group Discussion Approach

Ram Singh, R. Saravanan, S.M. Feroze, L. Devarani and Thelma Paris†

The paper attempts to assess the consequences of climate change on rural livelihood of farmers in Ri-bhoi district of Meghalaya. Two villages, namely, Umden Arka and Pyllun village were considered for focus group discussion. Two focus groups in each village, viz., men and women having 20 farmers were organised for discussion to examme the effect of climate change. The farmers reported that rainfall was more in earlier days than recent days and less erratic, about 90 to 95 per cent men

*P.G. Scholar and Professor and Head, Department of Agricultural Economics, Junagadh Agricultural University, Junagadh – 362 001 (Gujarat), respectively.

†School of Social Sciences, College of Post Graduate Studies (CAU), Barapani and Socio-economist, Division of Social Sciences, International Rice Research Institute, Philippines, respectively.

and women reported yield loss due to climate change in both the villages. Rising temperature was reported by 80 and 90 per cent men and women, respectively in Umden Arka village and by 90 per cent of both men and women in Pyllun village. The drought, floods and cyclones incidence did not occur with the climate change. The incidence of livestock diseases increased and loss in milk yield was reported as severe effects of climate change in both the villages which ultimately affected the income and livelihood of the farmers.The study suggested the need of area based or site specific varieties of seeds to be developed to cope with the changing climatic situations. These varieties should be heat tolerant, submerged tolerant and resistant to insects and pests. Besides some drainage technologies should reach the farmers' field to curb the flood situation in the study area.

Climate Change and Indian Agriculture

V.T. Raju*

Climate change is no longer a distant concern, but a serious threat to development and poverty eradication. The Inter governmental Panel on Climate Change (IPCC) has projected that the global mean surface temperature will rise by 2.0^0C to 4.5^0C by 2100 due to increase in greenhouse gases (GHGs). The recent IPCC report and several other studies indicate a probability of 10 to 40 per cent loss in crop production in India with increase in temperature by 2080-2100 and decrease in irrigation water. Rice yields are projected to decline by 5 to 12 per cent over India and China with a further 2^0C rise in temperature. India could lose 4 to 5 million tonnes of wheat production with every rise of 1^oC temperature throughout the growing period. Global climate change has considerable implications for Indian agriculture and hence on our food security and farmers' livelihood. Urgent steps need to be taken to increase adaptive capacity. This would require increased support of adaptation research, developing regionally differential contingency plans for temperature and rainfall related risks, evolve new land use systems including heat and drought tolerant varieties of crops adaptive to climate variability and increasing food demand. Hence, greater attention is now needed on adaptation to climate change, which includes increased investment, adaptation and mitigation research, improved land use and natural resource management policies, improved risk management through crop insurance, etc.

*Professor of Agricultural Economics and Dean, College of Post Graduate Studies, Central Agricultural University, Umiam – 793 103 (Meghalaya).

Development of Watershed – A Mitigation Measure to Climate Change in Rainfed Areas: A Case Study in Andhra Pradesh

R. Vijaya Kumari†

An attempt is made to assess the impact of watershed programmes implemented in Karimnagar district in terms of certain qualitative and quantitative parameters that will have an ultimate impact on the socio-economic conditions of the farmers. The State District Rural Development Agency is implementing several watershed programmes in the state through the District Water Management Agencies (DWMA) in the districts under different schemes. A case study of the assessment of 34 watershed programmes implemented by DWMA in Karimnagar district in Andhra Pradesh, that were implemented through non-government agencies as project implementing agencies (PIAs) has indicated significant impact on several quantitative and qualitative parameters like rejuvenation and increase in water level in wells, additional net area brought under cultivation, reduction of labour migration, increase of milk yield per day, increase of agriculture and horticulture crops productivity, etc. Thus, the results of the opinion survey of the beneficiaries indicated positive impact of the watershed technology on agriculture and income of the farmers. However, a few lacunae like, timely sanction and release of budget, regular monitoring of works, increased women participation, proper maintenance of records and structures were identified which could be rectified through efficient management of natural resources i.e., land and water. The study has stressed the need for development of watersheds in rainfed areas as a mitigation measure to overcome the effects of climate change.

Climate Change and Indian Agricultural Sector: An Integrated Impact Assessment

Deepak Shah*

The study not only assesses the impact of climate change on the agriculture sector of India but also recommends the future strategies for sustainable development, adaptation and other policy decisions since it is important to have an integrated assessment of climate change. India faces a major threat from changes in climate since its economy is closely tied to natural-resource-base and climate-sensitive sectors such as agriculture, water, and forestry that happen to be the most vulnerable sectors. India is poorly equipped to cope effectively with the adversities of climate change due to low capabilities, weak institutional mechanisms, and lack of access to

†Associate Professor, Department of Agricultural Economics, College of Agriculture, A.N.G. Ranga Agricultural University, Hyderabad – 500 030 (Andhra Pradesh).

*Faculty Member, Gokhale Institute of Politics and Economics (Deemed to be a University), Pune – 411 004 (Maharashtra).

adequate resources. Wheat production in the country may decline after 2020 and rice production may be adversely impacted in the eastern states. The eastern region would witness increased temperatures and decreased radiation, resulting in fewer grains and shorter grain filling durations. On the other hand, the potential decline in yields owing to increased temperatures in northern India will be offset by higher radiation, resulting in lower impacts of climate change. There is a possibility of a loss of 4–5 million tonnes in annual wheat production with every 1^0C rise in temperature even after considering the carbon fertilisation effect. The climate change will affect various crops during the entire growing period owing to extreme weather events. The adaptability of crops to climate variability would acquire significant dimension as frequent occurrence of extreme whether conditions may dictate as to how to cope up with the situation. The climate change will include extreme heat as well as cold waves, increased variability with respect to *rabi* and *kharif* crop production, increased extreme weather events in general, erratic onset as well as advances of monsoon, etc. Since farm production is likely to be adversely affected, the climate change will result in increased water management practices, improving land, soil and nutrition management practices, reduction in inefficiency in water use, preservation and enhancement of plant and animal genetic resources, adjustment to the pattern of food consumption, promotion of eco-friendly use adaptation, adaptation to ecosystem based approaches of risk management, shift in cropping pattern, adaptation to integrated farming system and integrated agro forestry systems, etc. There are areas where adaptation programme have already been developed and these include crop improvement, risk financing, draught proofing, disaster management, etc. Adapting agricultural systems to climate change is urgent because its impact is already evident and the trends will continue even if emissions of green house gases are stabilised at current levels.

Impact of Climate Change on Crop Water Demand and Cereals Production in India

O. P. Singh, P. S. Badal, P. K. Singh, Rakesh Singh and H P. Singh†

The objectives of the study are to estimate the impact of climate change on crop water demand and analyse the changes in the production of cereals due to climate change. The study is based on secondary data collected from various published sources. It is concluded that change in temperature and rainfall pattern alongwith availability of water, for crop production, pests and diseases are likely to significantly and adversely affect the potential of agricultural production. Total water resources of the country were estimated to be 1867 BCM and utilisable water was found to be 1123 BCM. Out of this, the share of ground and surface water was 433 and 690

†Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi – 221 005.

BCM, respectively. To cope-up with climate change, several adaptive measures should be adopted which include improving irrigation efficiency of surface irrigation system by reducing water losses from canal system and shifting cropping pattern towards water efficient crops in command area; develop heat and drought tolerance crop varieties; popularisation of resource conservation technologies, i.e., zero/reduce tillage to save input and enhance output; provide crop insurance, subsidy, price policies and change in land use; and paddy growers may adopt System of Rice Intensification (SRI)/alternate wet and dry systems in low rainfall area to cope-up irrigation water scarcity.

Global Climate Change and Its Impact on Indian Agriculture

Swami Prakash Srivastava*

Agriculture production in many countries, including India will be impacted by climate variability, it is estimated that greater loss is expected in *rabi* as compared to *kharif* crops. The worst affected would be millions of small and marginal farmers and people who are already the most vulnerable. Rising sea levels due to climate change would force communities in low laying coastal areas and river deltas to move to higher ground levels. Similarly, increase in frequency of droughts due to climate change would force farmers and pastorals, who rely on rainfall to raise their crops and livestock to migrate to other areas in search of land and water. According to World Meteorological Organisation, climate change can adversely impact global environment, agricultural productivity and the quality of human life. More importantly in developing countries, it will be difficult for farmers to carry on farming in the increased temperatures. The frequent climate change, particularly low rainfall and warming has posed serious threat to sustainable agriculture. Low rainfall has resulted in ground water depletion because of draining of water for irrigation and warming has affected the yield of rice and wheat. Agriculture will be impacted by climate change in several ways. There will be reduced crop yield. Climate change can shorten *rabi* season and decrease yield. Vulnerability to diseases and pest attack increases. High temperatures affects the quality of produce. Increase in temperature can reduce 1000 grain weight and the amylase content and also adversely affect grain elongation and aroma in basmati. Increase in temperature causes distress to dairy animals affecting milk production. Studies indicated that India would lose about 1.8 million tonnes of milk production due to climate change by 2020, 11.7 million tonnes by 2050 and 23.5 million tonnes of wheat by 2080. It is not reversible. But with the help of simple adaptation strategies, viz., change in planting date and varieties can reduce the extent of loss caused by high temperature. Chilling is very crucial for good apple yields. Agriculture development in India needs to focus on reducing

*Associate Professor, Department of Economics, Dayalbagh Deemed University, Agra – 282 005 (Uttar Pradesh).

green house gas emissions through measures, such as significant reduction of deforestation; improving forest conservation and management; effective control of wildfires; promotion of agro-forestry for food for energy; soil carbon sequestration; restoring land through controlled grazing; improving nutrition for ruminant livestock; efficient management of livestock waste (through biogas recovery); and developing strategies that conserve soil and water resources by improving their quality, availability and efficiency of use. While a National Network Project "Impact, Adaptability and vulnerability of Indian agriculture to climate change" has been launched with a focus on impact of climate change on different sectors of agricultural production, it is necessary to make sufficient investments to support climate change to adaptation, mitigation, technology development, transfer and dissemination among farmers.

Impact of Climate Change on Economy of Livestock and Livestock Products in Uttar Pradesh

Babu Singh, Rakesh Kr. Singh, Birender Kumar and Yogesh Yadav[†]

The paper emphasises the effect of climate change on the livestock sector and seeks to work out the trends in production of milk and its products in Uttar Pradesh for judging its potential in future. The analysis is based on census and secondary data obtained from various sources. The annual compound growth rate of agriculture was 2.3 per cent during the 1990s as against 2.9 per cent in the 1980s. Crop, livestock, fisheries and forestry constitute the core sectors of agriculture. The share of livestock sector, on the other hand, has grown by 6 per cent from 18 per cent in 1981-82 to 24 per cent in 1997-98. This sector is growing impressively in Uttar Pradesh. It is reflected from the increasing share of livestock in the gross value of agricultural output from 18 per cent in 1981-82 to 24 per cent in 2007-2008. There were 19.8 million cattle, 17.9 million buffaloes, 10.7 million goats and 3.2 million pigs. Annually the state producers more than 11 million tonnes of milk and over 116 thousand metric tonnes of meat from buffalo and small ruminants. Share of milk production was growing impressively in the value of livestock output. The annual growth in milk production grew at an impressive rate of 5.5 per cent during 1990s, which was about 4.8 per cent during 1980s. The potential of this sector has not yet fully capitalised. This sector is also important for the livelihood of small and marginal farmers. To raise income and generate employment opportunities for landless labour, marginal and small farmers, the livestock sector needs special attention. The contribution of livestock sector to food availability in meat, eggs, milk and milk products are the main forms of food, which are made available from

[†]Economics and Statistics, C.S. Azad University of Agriculture and Technology, Kanpur – 200 802 (Uttar Pradesh).

livestock sector. If in the state climate position being normal this production shows better result and enhance the quality of life the rural masses. Marketing of livestock animals, cattle, milk and milk products, meat (goats, poultry and pigs) and eggs, wools hides and skins-have been performed in a condition of market failure in entire Uttar Pradesh. If marketing requirements and production technologies have to be tied together, the future of livestock development and growth in Uttar Pradesh would be bright and thus, study suggests that market prices, practices and facilities might be designed in order to give favourable net return to the farmers, the future growth may accelerate to the desirable extent. In the state some products depicted increasing trends and some showed decreasing trends, for keeping in view the livestock products in relation of rural areas development.

Impact of Climate Change and Policy Response in India

Hem Chandra Lal Das*

Climate change is a serious and long term global challenge as it is one of the greatest environmental social and economic threats facing the planet. The overall impact of baseline climate change by 2080 is a drastic reduction in agriucltural productivity (16 per cent without carbon fertilisation and 3 per cent with carbon fertilisation).

The impact of climate change on agriculture is determental, an increase of 2°C to 4°C in temperature is predicted to result in yield reduction which will reduce the potential yield of wheat in most regions. The regions with higher potential productivity such as Northern India are relatively less impacted by climate change than areas with lower potential productivity. Reduction in yield as a result of climate change is predicted to be more pronounced for rainfed crops as against the irrigated crops, and under limited water supply situations, because there is no coping mechanism for rainfall variability. In sub-tropical environment, the potential yield of wheat is expected to decrease.

India's agricultural policies of tomorrow must factor in climate change concerns. Heat resistant, less water consumption, high yielding and faster growing varieties are some of the measures suggested more saline water will be coming inland, we must find out utilisation of this water in the agricultural sector, cropping pattern will have to be looked at afresh in view of climate chagne. Export of agricultural items like sugar which uses so much of water to grow sugarcane, should be discourged. Because ulternately it is not sugar which is being exported, it is virtual water which is being exported.

*University Professor, Post Graduate Department of Economics, M.S. College, Motihari – 845 401 (Bihar).

Planning of Crops Under Different Rainfall Situations in Kymore Plateau and Satpura Hills Zone of Madhya Pradesh

S.K. Gupta†

An attempt has been made in this paper look into the crop planning under different rainfall situation in Kymore plateau and Satpura hills zone of Madhya Pradesh. During the recent past our country has faced frequent weather vagaries, mainly related with aberrations in monsoons, e.g., onset and withdrawal of monsoon, occurrence of intermittent drought which caused instability in food grain production largely depends on the south-west monsoons. Kymore plateau and Satpura Hills zone lies in the eastern part of the state. The climate of the zone is generally hot and dry. Annual rainfall in this zone varies from 1150 to 1350 mm. Most of the rainfall is received during the months of July and August followed by June and September. Very little precipitation is received during post-rainy and witer seasons. The serious implications for crop productivity experienced in the month of September as *kharif* crops are most sensitive to moisture stress and availability of soil moisture to *rabi* crops is also affected. For maximising crop production selection of crops and their varieties in the rhythm of monsoon behaviour is prerequisite. Various agronomic practices i.e. nutrient management, weed management. IPC, soil moisture conservation etc. are equally important. For this purpose contingent crop planning based on monsoon behaviours will not only help to enhance crop production but minimise the losses incurred due to abrupt weather conditions. The production of crops can be maximised under the above situations by adopting the recommended varieties and package of agronomous practices for different crops.

Adaptation and Mitigation Strategies for Livestock: Myths and Realities in the Indian Conditions

Sumit Mahajan, Shivraj Singh Rathore, Bulbul Nagrale and K.K. Datta*

The paper tries to demystify certain myths associated with the strategies applicable in the context of small holders in the livestock production in India as well as explore the ground realities. The present policy of indiscriminate crossbreeding of local cattle with exotic cattle should be reviewed and reoriented for smallholder dairy farmers especially, in dry and rainfed regions where there is scarcity of fodder and water which are required heavily by crossbred cattle. The study clearly reflects that the adaptation research should be country specific as the strategies suitable for one country may not be viable for the others due to considerable difference in local

†Principal Scientist (Agril. Economics), and Technical Officer to Dean, Faculty of Agricultrue, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur – 482 004 (Madhya Pradesh).

*National Dairy Research Institute, Karnal – 132001 (Haryana).

conditions of different countries. Therefore measures should be taken to increase the resource-base of smallholder farmers. These measures include implementation of land reforms, providing subsidies and access to credit by smallholder farmers. The government should invest heavily on common property resources for their construction, development and maintenance and should provide economic incentives for mass participation of masses.

Impact of Climate Change on Agriculture and Coping Measures to Mitigate the Effect of Climate Change

S. Sakamma, K.B. Umesh, Vilas Jadhav and S.M. Vanitha†

Climate change is variation in climatic variables such as rainfall, temperature and relative humidity over a period of time, leading to the extremities like drought, floods and so on. Climate change due to natural causes which is in small amount is inevitable, but climate change due to human induced causes has made it the issue of concern world over. Climate change will affect agriculture through their direct and indirect effects on crops, soils, livestock, fisheries and pests. The global atmospheric concentration of carbon dioxide, methane and mitous oxides and other green house gases (GHGs) has increased considerably. Besides agriculture sector is the major contributor to global warming next to energy sector. Climate change is likely to reduce agricultural productivity, production stability and incomes thus necessitating a significant transformation in order to meet the related challenges of food security and climate change, by way of developing climate smart Agriculture is thus crucial to increase the resilience and productivity of agricultural production system. There are several practices called climate smart decisions that are followed by the farmers, that go unnoticed yet their contribution to reduce GHGs is immense.

The Impact of Climate Change on Karnataka's Agriculture – By Spatial Techniques

K.V. Asha Latha and Munisamy Gopinath*

The paper studies the impact of climate change on Karnataka's agriculture. Specially, it aims to examine the effect of fertiliser and labour inputs on crop productivity and to investigate the impact of climate variables such as rainfall and temperature crop production. The study employs a panel data methodology by using stochastic frontier analysis and spatial lag using a 40-year district –level panel data set covering all the districts of Karnataka State. The results reveal that the

†Ph.D. Scholars and ** Professor, Dept. of Agricultural Economics, University of Agricultural Sciences, G.K.V.K., Bangalore-560 065 (Karnataka).

*University of Agricultural Sciences, Dharwad, Karnataka - 580 005 and Oregon State University, 213, Ballard hall, Corvallis, respectively.

impact of weather parameters on Karnataka's agriculture is likely to be negative over the period. Research also indicates that there is a significant impact of spatial correlation with respect to weather parameters. Since agriculture makes up roughly 20 percent of India's gross domestic product, this implies a cost of climate change on Indian agriculture is likely to be negative over time. Neighboring weather parameters exert a direct effect on the value of the dependent variable itself. The spatial effect of annual rainfall induces a higher production, where as spatial dependence of average temperature has inverse relation on production. The fertiliser, bullock labour and land variables have significant increase in the production. Besides SFA is better over regression. These findings suggest that climate change is likely to impose significant costs on the Indian economy unless farmers can quickly recognise and adapt to increasing temperatures. It is advisable that any land reforms in the area take account of this traditional climate risk mitigation strategy.

Climate Change Trends in Agriculture:
Evidence from Himachal Pradesh

M.S. Pathania and J.S. Guleria[†]

A study was conducted in Himachal Pradesh to examine the implications of climate change on agriculture. It has analysed the changes in different parameters that affect climate and determine the ability of farmers to detect climate change is based on both secondary and primary data. In all 80 farmers from three villages of Nagrota Bagwan and Baijnath block of the study district were selected. The study observed that area under wheat and rice have increased significantly in India, but, area under pulses has remained almost stagnant. The production of foodgrains has increased continuously. The production and productivity of pulses has not shown any major improvement during the last five decades. The analysis of different factors responsible for climate change in the state indicated decreasing trend in the amount of precipitation among different districts. The high variability was noted in rainfall over the period in all the districts. Very high and significant positive correlation was observed between rainfall and production as well as rainfall and productivity of cereal crops in some districts, while in other districts there was also positive but non-significant correlation. The study indicated significant decrease of snowfall. The flow of water in different rivers over time showed a decreasing trend. So, it was concluded that there was decrease in water availability for hydro- electric power generation and irrigation. The contribution of secondary sector to SGDP has increased. Farmer's perceptions regarding climate change were increase in temperature during summers, unpredictable rain fall, uneven distribution rainfall, prolonged summers, delayed and less snowfall, delayed onset of winter, delayed onset of Southwest monsoon, short

†Department of Agricultural Economics, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur - 176 062 (Himachal Pradesh).

duration winters, etc. The variables such as age, farming experience, education level, innovativeness, consciousness to environment and exposures to mass media had a positive and significant relationship with farmer perceptions to climate change. Therefore, there is a need of developing suitable varieties for rainfed cultivation under late sown condition. There are signals of climate change in Himachal Pradesh which have clearly seen in receding precipitations and rise of temperature in different regions of the state. Several options relating to technology transfer, their adoption, appropriate policies and land and water management for crop production are available which can help to minimise the negative impacts of climatic factors. The study revealed that significant numbers of farmers believe that temperatures have increased and the precipitation has declined along with late onset and early withdrawal of monsoon with long dry spells. Therefore, there is a need to adjust the cropping pattern with the changing trend of climatic factors and development of crop varieties that will resistant to climate change. There is dire need to improve farmers' ability to use water more efficiently and better management of their fragile soil to accommodate the shocks of climate change. Both short term and long term strategies need to be formulated to cope up with the rainfed cultivation alongwith proper management of soil and water resources to increase their productivity in the state. The exploitation of soil and water to increase the productivity needs besides adoption of water saving technologies are some of the measures suggested.

Regional Climatic Change and Natural Resources Over Decades: A Perception Analysis

A.K. Gauraha*

The study aims to examine the impact of climatic change on natural resources in different agro-climatic sub-zones in Chhattisgarh. The study is based on various studies, conducted by the authors at different periods of time. The farmers' perception regarding degradation of natural resources and different causes of degradation of natural resources were collected through Participation Rural Appraisal method. The results of the study indicated that in the 1970s the degradation of natural resources especially the forest resources has been observed to be more rapid as compared to land, water and other resources in almost all the sub-regions specially in tribal dominated districts of Chhattisgarh. During the 1970s farmers observed that there is no severe effect of climatic change on natural resources. In the 1980s decade the rate of degradation of land, water, biodiversity, forest and mineral resources were very fast in almost all the sub-regions due to mismanagement of common pool resources, climatic change, market influence, rapid growth of population and social conflicts at the grassroot level. However, in Bastar plateau and Northern hill region

*Associate Professor, Department of Agricultural Economics, Indira Gandhi Agricultural University, Raipur - 492 006 (Chhattisgarh).

some impact of technology on agriculture was observed. This was due to good rainfall and proper distribution of rains in the different seasons. In the 1990s the over-utilisation of natural resources and heavy rains in very small period were observed due to which the demand and supply gaps of natural resources had increased in the state. On the basis of farmers perceptions it is essential to manage the natural resources through participation of local people, Government and non-governmental organisations.

An Economic Analysis of Impact of Climate Change on Selected Crops of Tamil Nadu

J.S. Amarnath[†], V. Karthik[‡] and T. Alagumani[†]

The paper attempts to analyse the effect of climatic change by measuring the relationship between weather parameters of rainfall, maximum and minimum temperature on production and productivity of selected crops of Tamil Nadu. For the purpose secondary data on area, production and productivity of selected crops, viz., sorghum, bajra, maize, groundnut, cotton and sugarcane and data on rainfall and the maximum and minimum temperature in Tamil Nadu were collected from published sources. The decadal trend of maximum temperature, minimum temperature and rainfall in Tamil Nadu showed that in general the minimum temperature was increasing while the maximum temperature was declining. Rainfall in Tamil Nadu exhibited a cyclical trend. The results of Cobb-Douglas production function showed that among the selected crops, production of sorghum and productivity of bajra were affected by maximum temperature negatively implying that this variable had negative impact on production of sorghum and productivity of bajra. Minimum and maximum temperature also had negative impact on production and productivity of groundnut. The study revealed that the extreme variations in temperature affected the productivity of bajra and groundnut and, production of sorghum and groundnut. The study called for suitable adaptation strategies like better farm management methods, irrigation networks and crop mixes to tide over climate change.

Contribution of National Agricultural Science Museum in Creating Awareness about Mitigating Effects of Climate Change

Sushila Kaul*

The National Agricultural Science Museum (NASM) is a unique museum of agriculture, situated in New Delhi, showcasing the universal issues pertaining to

†Professors, ‡M.Sc. (Agriculture) Student, Department of Agricultural Economics, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai – 625 104.

* Sr. Scientist and In-charge, National Agricultural Science Museum (NASM), New Delhi – 110 012.

agriculture, highlighting the effects of climate change on agriculture. Climate science is complex and interdisciplinary, and therefore not an easy subject to teach, however, NASM helps in imparting knowledge of the natural processes involved in global climate change. It provides a long-term repository of climate-relevant research materials for present and future studies and brings this knowledge to various audiences, ranging from scholarly to the lay public. The unique contribution of the NASM is that it provides a long-term perspective about human-caused changes in climate. The NASM strives to educate the students, farmers, researchers as well as general public about climate change research findings.

Agricultural Sustainability and Its Policy Framework in Orissa – An Approach

Lakshmi Dhar Hatai and Chandra Sen[†]

An attempt has been made to examine a suitable method for Sustainable Livelihood Security Index (SLSI) for agricultural sustainability and to evaluate the relative agricultural sustainability and suggest policy implications in different districts of Orissa. Orissa is purposively selected as the state consisted of 30 districts and there is great inequality; improper management and over-exploitation of natural resources and explosion of population have created a threat to ecological balance, economic aspects and social status in different districts of the state. For instance, total twelve variables have been selected to illustrate three dimensions of Sustainable Development of Agriculture (SDA). Despite their variation and limitations, the selected variables do have a good capacity to reflect the picture of the overall ecological, economic and equity aspects of a district's agricultural systems.

The findings of this study revealed that the values of Ecological Security Index (ESI), Economic Efficiency Index (EEI) and Social Equity Index (SEI) range vary from 0.68 to 0.141, 0.75 to 0.075 and 0.701 to 0.209 respectively. This shows that the agricultural systems of all the districts of Orissa display wide variations in their ecological and social equity aspects relative to their economic aspects. While the SLSI indicates a range from 0.586 to 0.181 and the SLSI* reflects a range from 0.621 to 0.212. The results indicate that there is significant variation between SLSI and SLSI*. It can be observed that the districts with the better SLSI ranks are often described as advanced districts using other ecological, economic and social indicators and vice-versa. Consequently, the overall performance of the districts in terms of their both SLSI and SLSI* showed that only 8 out of the 30 districts in Orissa have an index of above 0.5, while thirteen districts have an SLSI lower than 0.4. Moreover, many of the districts of coastal Orissa have better performance in agricultural

†Assistant Professor (Agril. Economics), College of Home Science, Central Agricultural University, Meghalaya – 794 005 and Professor (Agril. Economics), Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221 005, respectively.

sustainability in comparison to the districts of western Orissa as a whole. Sustainable Agriculture (SA) became a dominant global concern for livelihood improvement and environmental stability. The future challenges and policy implications of the SLSI approach has received increasing attention from the fact that it helps not only to establish inter-districts priority for the allocation of agricultural investment but also to prioritise the activities and programmes relevant to each district for sustainable agricultural development. The development as well as proper utilisation of micro-indicators to the agricultural situation of Orissa should be emphasised.

Impact of Climate Change on Karnataka's Agriculture

Aravind Kammar, S.M. Mundinamani and B.L. Patil*

The study aims to analyse the impact of climate change on rainfall distribution pattern and crop productivity of major crops in Karnataka. The time series data on normal and actual rainfall, cropped area, production and productivity of major crops were collected for the period from 1979-80 to 2007-08. Tabular and regression analyses were employed to analyse the data. The results of the study revealed that rainfall in Karnataka during the study period was erratic. Hence, agriculture sector in general and almost all major crops in particular have suffered extensively during 2001-02, 2002-03 and 2003-04 due to severe drought. Actual rainfall was found to have a positive and significant impact on yield of major crops except in case of jowar, groundnut, sunflower and sugarcane. On the contrary, deviation of actual rainfall from normal was found to have a negative and significant impact on yield of major crops. The findings of the study revealed the adverse effect of climate change on yield of major crops in the State. To overcome the loss of yield due to climate the meteorological department must disseminate weather information to farmers well in advance through weather stations located in different parts of the State. This may guide the farming community to adopt suitable coping mechanisms to overcome the problems of climate change on crop yield.

Groundwater Conditions in Malshiras Tehsil

H.S. Ranaware†

In this paper an attempt is made to study groundwater conditions in Malshiras tehsil, one of the important tehsils in Solapur district in Maharashtra state. The study considered only tubewells used only for irrigation purposes and 6 villages were

*Senior Research Fellow, Professor and Head and Associate Professor, respectively, Department of Agricultural Economics, University of Agricultural Sciences, Dharwad – 580 005 (Karnataka).

†Associate Professor and Head, Department of Economics, Shankarrao Mohite Mahavidyalaya, Akluj – 413 101 (Maharashtra).

selected in the study area. This study relied on primary as well as secondary data. For the collection of primary data 'lead' research method was adopted and a total of 30 tubewell farmers have been selected randomly for the study purpose. The major findings of this study are that out of the total 30 tubewell farmers none of the farmers tried to recharge the ground water for increasing the ground water level in the study area. It is also found that the East part of Akluj village the banks of Nira river (e.g. Ganeshgaon area) is seriously polluted, due to industrial wastage and drainage water flow in Nira river as compared to the west part of Akluj village. Under Ujni canal command area village (i.e., Bondle) groundwater is polluted due to Ujni canal water due to industrial waste and drainage. Under Bhatghar canal command area village (i.e. Mandve) the quality of ground water has changed but not polluted. It is also found, in hill and foot hill zone, where there is no polluted river and no canal, (i.e. Bacheri village) ground water level is low, but the quality of water has not changed and ground water is not polluted, which make is potable for drinking and irrigation. But one thing is found in all zones in study area is that the level of ground water is constant due to load shedding. Therefore the study suggests that, it is the responsibility of every farmer to try to best recharge their tubewells ground water in rainy season and not mix industrial waste and drainage in river water before purification.

Land and Water Use Practices for Sustainable Livelihood of Smallholders' in Climate Change Perspective

U.H. Kumar and S.S.P. Sharma*

The emerging challenges in the recent years relating to land and water use practices are that its costs and benefits are distributed unevenly and land and water related and watershed projects may be exacerbating precisely the water shortages they aim at to overcome. Keeping in view of these socio-economic and technical challenges, the present paper has made an attempt to examine the different dimensions of the role of micro-level environment elements to sustain the livelihoods of small and marginal farmers who constitute 78.2 per cent of the total holdings. Specifically it examines the effectiveness of land and water use practices of small and marginal farmers in tune with the emerging scenario of climate change and to understand the livelihood security under the existing land and water use practices. The paper is based on a comprehensive field based study undertaken at National Institute of Rural Development, Hyderabad during 2008-09 in four states, viz., Gujarat, Tamil Nadu, Jharkhand and West Bengal. Land and water use practices in the four sample states is to bring together the various dimensions of natural resources development under an overarching perspective of equitable, productive and

*Assistant Professor and Professor and Head, respectively, Centre for Water and Land Resource National Institute of Rural Development, Hyderabad – 500 030.

sustainable development. These local level practices in tune to climate change and local level available resource base are desirable, where micro-environment element interventions are more suitable to meet climate change effects at local level. Watershed is an excellent exercise of micro-environment for putting together all the elements (different practices) of area development of improved biomass, efficient water use and internalised production systems. These aspects are keenly observed in these four sample states. The interventions and group dynamics approach is feasible itself needs continuous follow up and active involvement of different stakeholders at all levels.

Adaptation to Climate Change through Efficient Crop Insurance

R. Jaya Kumaravaradan[†], Pramod Kumar[†] and D.R. Singh[‡]

The study has been undertaken to analyse the performance of crop insurance in Tamil Nadu, which is one of the major agrarian states often affected by natural calamities. Specifically it aims to analyse the performance of National Agricultural Insurance Scheme (NAIS) as an adaptation measure to overcome the adverse effects of climate change on the agriculture sector of Tamil Nadu. The study is based on primary data collected during the year 2009 from 180 rice farmers and 20 officials involved in the ground level implementation of the scheme. A very low coverage of NAIS in the state shows that the scheme has a huge scope to expand. The safety net provided by crop insurance enabled the farmers to specialise their production. Though insurance helped the farmers to afford high value inputs, their indiscriminate use has reduced the efficiency of farming. The positive influence of credit accessibility on adoption emphasises the rationale of credit-linked crop insurance. Certain procedural difficulties hinder the convenient participation of farmers in the scheme. Separate yield assessment for irrigated and rainfed lands; and improvement in the methodology of crop cutting experiments are some of the suggestions that emerged from the discussion with the officials. The study also proposed some policies for the effective implementation of crop insurance to benefit all its stakeholders.

† Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi – 110 012 and ‡Indian Agricultural Statistics Research Institute, New Delhi – 110 012.

An Assessment of Climate Change and Its Effects on Agricultural Sector in India

N. Saraswathy and T. Selvakumar*

There exists significant concern at present throughout the world about the effects of climatic changes, as climate is one of the main determinants of agricultural production and it might cause variability in agricultural production. Researchers and administrators are concerned with the potential damages and benefits that may arise in future from climate change and its impacts on agriculture. In this context the study deals with the climatic factors, challenges of global warming, green house gases emissions in India, effect of global warming on agriculture, agriculture and food production, changes in extent of rainfall and patterns, efforts to mitigate climate change in the agriculture sector and the conclusions are drawn accordingly. The results of the study indicate that India's capacity to cope with or adapt to climate is severely limited by the fact that it is a low income country facing serious resource constraints. These deficiencies in adaptive capacity can be overcome only through rapid development. Without accelerated economic and social development, the future generations in India would remain extremely vulnerable to the impacts of climate change. At the same time India should continue to contribute to the global mitigation efforts by implementing "win win" measures.

An Assessment of Vulnerability of Farmers to Climate Change in Agro-Climatic Zones of North Karnataka

S.P. Subash†, V.R. Kiresur‡ and G.P. Shivaswamy†

The paper assesses the vulnerability of farming communities to climate change in different agro-climatic zones of North Karnataka, using primary and secondary data drawn from various sources. The 15 vulnerability criteria proxies were employed to study the extent of vulnerability. Each criterion was given an optimum value based on national/state average value and the value below or above the optimum indicated their degree of sensitiveness, which was classified as severe vulnerability, moderate vulnerability and less vulnerability. Based on the direct and interaction points obtained for a particular area, the vulnerability scale of a region/area was classified into five scales. The results of the study indicated that the North Eastern Transitional Zone is the most vulnerable agro-climatic zone followed by North Eastern Dry Zone,

*Senior Professor and Head, Department of Rural Development Studies, School of Economics, Madurai Kamaraj University, Madurai (Tamil Nadu) and Assistant Professor in Economics, Department of Management Studies, HKRH College, Uthamapalayam, Theni (Tamil Nadu).

†Department of Agricultural Economics, University of Agricultural Sciences, Dharwad – 580 005 (Karnataka) and ‡Research Program on Markets, Institutions and Policies, International Crops Research Institute for the Semi-Arid Tropics, Patancheru – 502 324 (Andhra Pradesh).

Northern Transitional Zone, Northern Dry Zone and Hilly/Coastal Zone. The vulnerability of the farmers of the region were mainly influenced by the factors such as forest cover, rate of food production per annum, existing irrigated area, percentage of poverty of the population and seasonal dry spell. The Northern Eastern Transitional Zone and North Eastern Dry Zone have shown severity in all these criteria making it the most vulnerable zone.

Regional Climatic Change-Farmers' Perceptions, Constraints and Economics of Pigeon Pea in Madhya Pradesh: A Micro Level Study

K.N.S. Banafar and M.R. Chandrakar*

The present study was conducted to examine the farmers' perceptions, cost and returns of in the production pigeon pea in Sehore district of Madhya Pradesh. A total of 120 pigeon pea growers were randomly selected for detailed economic analysis from twelve villages from different farm size groups, i.e., small (up to 1 ha), medium (> 1-2 ha) and large (above 2 ha) farms. Primary data from the selected farmers were collected through personal interview method using well structured questionnaire and schedule. The study revealed that the pigeon pea is the most important pulse crop of *kharif* season in the study area. On an average pigeon pea occupied 11.25 per cent area of total cropped area on the sampled farms. The average cost of cultivation per hectare of pigeon pea was observed to be Rs. 8813. The cost of cultivation of pigeon pea per hectare showed a rising trend with the increase in the farm size. The average yield of pigeon pea on sample farm was observed to be 8.67 quintals per hectare. The average input output ratio was worked out to be 1:1.41. It increased with the increase in the farm size because of higher net returns per hectare in relation to the total input cost. The farmer perception analysis has been done to workout the constraints in production of pigeon pea. The major socio-economic constraints in production of pigeon pea were the unavailability of improved and high yielding variety seed, cattle grazing problems, lack of irrigation, lack of knowledge of package of practices, poor economic conditions of small farmers, insect pest and disease problems etc. During flowering season high intensity of rainfall causes flower dropping in pigeon pea, cloudy weather and humidity attracts insect pest and disease, long sunshine hours are also favourable for attack of insect pest and disease, wind velocity also increases migration of insect in the direction of wind. The study suggested the need to adopt production system approach to linking to adopt production, technology, credit, marketing and processing as was done under Oilseed Technology Mission (OTM) to raise the production of pigeon pea in the study area. To overcome the problems of cattle grazing particularly in *kharif* season strong institutional arrangements must be developed by local people through co-operation.

*Department of Agricultural Economics, Indira Gandhi Agricultural University, Raipur - 492 006 (Chhattisgarh).

Climate Change Impacts on Groundwater Extraction Cost: Who are the Gainers and Losers?

A. Narayanamoorthy†

An attempt is made to study the climate change impacts on the cost of well and groundwater using survey data of 234 borewell owning farmers selected from two regions having different agro-economic settings in Pudukkottai district of Tamil Nadu. The study showed that the dugwell or borewell owning farmers had to incur a huge exra cost on account of modifications of their wells in order to cope-up with the fast decline of groundwater level, which occurred mainly due to wide variability in rainfall. Majority of the farmers have incurred substantial cost on altering the existing well structures that increased their capital cost of well substantially. The modification cost alone accounted for about 33-48 per cent of the real capital of borewells and dugells. The extraction cost of groundwater is found to be higher for borewells and dugwells owning farmers (who are also resource poor farmers) as compared to the farmers owning deep borewells fitted with submersible pumpsets. This study suggests a few supply and demand management strategies to tackle the climate change induced depletion of groundwater and to protect the resource poor farmers from it.

Adaptability to Climate Change: An Impact Analysis of NABARD's Watershed and Micro Irrigation Initiatives for Sustainable Agricultural Development

K.C. Badatya*

The basic objective of the paper is to assess NABARD's adaptation strategies to climate change with emphasis on two major flagship adaptation programmes of NABARD, i.e., watershed development and micro irrigation initiatives taken up under Watershed Development Fund (WDF) and Rural Infrastructure Development Fund (RIDF) in Andhra Pradesh. Primary data from a sample of 194 beneficiaries were used to assess the people's participation as also to evaluate the overall impact of watershed development in four watersheds, viz., Nethigutlapalli, Kosuvaripalli watersheds in Chittoor district and Teliki and Kothapalli watersheds in Cuddapah district in Andhra Pradesh. Similarly, data on 174 micro irrigation users covering three districts, viz., Ranga Reddy, Ananthapur and Mahabubnagar were used to assess the impact of micro irrigation. The impact assessment studies conducted on

†NABARD Chair Professor and Director, Department of Economics and Rural Development, Alagappa University, Karaikudi – 630 003 (Tamil Nadu).

*Assistant General Manager, National Bank for Agriculture and Rural Development (NABARD), Bandra (East), Mumbai-400 051.

watershed projects of NABARD revealed significant positive results. The structures created under watershed programme benefited the surrounding area to enhance the soil moisture and recharging of wells, tanks, etc., as a result the irrigation coverage increased by about 39.6 per cent in the post-watershed (PoW) period. The cultivable area increased in the PoW period during *kharif*, rabi and summer seasons. There is also reduction in distress migration from the villages surrounding the watershed areas, because of improved agricultural production and farm diversity, which declined 119 per cent in the PoW period. Similarly, the impact assessment studies conducted on micro irrigation systems supported under RIDF in Andhra Pradesh revealed that seasonal water requirement (SWR) for sweet orange, guava, groundnut and vegetables came down by 41, 57, 26 and 16 per cent, respectively in the post-micro irrigation period. There was an increase in land use which had gone up by 23.4 per cent in the post-MIS period. The irrigated area of sample farmers increased from 191.05 ha in the pre MIS to 311.74 ha in the post- MIS. Shift in the cropping pattern from field crops like, jowar, bajra, paddy to different horticultural crops like, banana, grapes, pomegranate, floriculture and fig was also observed in the post MIS period. The change in the cropped area was highest in the case of mango , followed by sapota, papaya, etc. NABARD's adaptation strategies to climate change emphasises on National Rural Health Mission (NRM) 'enhancing livelihoods and quality of life of the rural community through improved resource conditions'. Considering NABARD's role in NRM sector, in future, NABARD would be in a position to play a pivotal role through rural financial institutions to achieve the mission as envisaged in National Action Plan to Climatic Change (NAPCC). Government may also think of instituting a NAPCC fund with in NABARD for providing low cost finance to the RFIs for taking up programmes/schemes as envisaged under NAPCC.

Estimation of Enteric Methane Estimation from Dairy Animals: A Case Study of Semi-Arid Region of Rajasthan

Prem Chand, Smita Sirohi and S.K. Sirohi*

The study estimated the enteric methane emission from dairy animals by generating region-specific emission factor in semi-arid eastern plan zone of Rajasthan using primary as well as secondary data. The emission factor for each category of dairy animals was generated using the Tier-II approach proposed by Inter-governmental Panel on Climate Change based on primary data collected from 120 households of Jaipur district of the zone. The results of study showed that the methane factors for lactating local cow, crossbred cow and buffalo were 144.19g, 203.78g and 198.41g/head/day respectively, while dry local cow, crossbred cow and buffalo emitted 124.85g, 190.29g and 173.74 g/head/day, respectively. A total of

*Ph.D. Scholar, Principal Scientist, DES&M Division, and Senior Scientist, DCN Division, respectively, National Dairy Research Institute, Karnal – 132 001 (Haryana).

10308.37 thousand tonnes of methane was emitted from enteric fermentation of dairy animals in the zone of which more than two-thirds was contributed by buffaloes. The methane emission per kg of milk production worked out to 75.72 g and was reported to be the highest in case of crossbred cattle. The study suggests for incorporating energy efficient diets such as concentrates and by-products of sugar industry, maintaining the livestock population in relation to carrying capacity, improving the productivity of animals, etc. as some of the possible options for reducing the methane emission in the zone.

Climate Change and Adaptation: Economy at Cross-Roads

Talwar Sabanna[†]

In order to understand climate change issue properly, one needs to comprehend the vulnerabilities of natural ecosystems and human environments to climatic shocks and changes. On the other hand, it implies that all the academic disciplines need to contribute to the discussion. Scientific challenge is high due to the complexity in climate system. There is even greater challenge in economics to decide on the proper allocation of the global public goods, i.e., a stable global climate. For developing countries like India, the challenge is to provide basic services and income opportunities to all its citizens and ensure a decent standard of living without embarking on a high-carbon intensive growth path. The challenge can also be seen as an opportunity to redefine the development and growth path through active policy formulation and institutional reforms. The progress made on development so far has actually fallen short of desirable outcomes as the bulk of the population still languishes under the yoke of poverty, largely dependent on agriculture, susceptible to climate conditions and other natural resources for livelihood and sustenance. The present and ongoing challenge that global warming and consequent climate change pose to the Indian developmental paradigm is immense in terms of the sheer numbers of vulnerable population who have so far failed to reap the benefits of developmental gains. There is also the possibility of the present developmental gains falling into jeopardy. Thus, it is noteworthy that the challenges posed by global warming and its associated climate change are new to the global developmental paradigm. For countries like India where a large section of the population are still in the clutches of poverty and low human development, climate change adds a entirely new dimension to the already existing gaps in development and thereby require a whole gamut of policy shifts and reprioritisation to address the emerging challenges.

†Associate Professor, Department of Economics, Rani Channamma University, Belgaum – 591 156 (Karnataka).