

Climate Change and Agriculture over India

Editors

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FOREWORD

Increased human activities accelerated the process of climate change in the recent past and increased the mean global surface temperature by 0.6°C over the past 100 years, a phenomenon known as global warming. Almost all the years in the current decade recoded extreme weather events, and the year 2007 has also been declared as the warmest year. The model outputs based on GHG emission rates have clearly brought out the seriousness of the problem and the impacts of such changes were documented well.

The climate projections over India indicate that temperature rise is likely to be around 3°C and rainfall increase is expected by 10-20 per cent over Central part of India by the end of this century. Whether the projections would become real or not, the occurrences of weather extremes like floods and droughts and cold and heat waves are not uncommon across the Country. For example, the winter 2007-08 was one of the worst cold waves, may be unique during the last 50 years, as far as the China is concerned. The estimated economy loss was about \$7.5 billion and forced nearly 1.8 million people to relocate. The cold wave during this year was even extended to Gujarat and Maharashtra. Both the States experienced a record low of night temperatures during the winter 2008. Similar was the cold wave in 2002-03 over the northern States of India, in Particular Himachal Pradesh, which led to the estimated crop loss up to 100% depending upon the type of crops.

The wheat production in the Country since last few years was not encouraging due to increase in temperature across the wheat growing regions during the reproductive phase of the crop. The recent imports of wheat are an indication to that effect. As per the FAO report, the wheat stocks have declined to their lowest levels since 1980. It could be attributed an unprecedented drought in Australia for two years in a row and unfavourable weather conductions in Argentina, Ukraine and Southern Russia- all principal wheat producing regions - have sharply reduced global output. Less understood but an obviously potent factor is the effect of global warming? Probably, the stagnation in Indian foodgrains

production since last one decade may be due to occurrence of extreme weather events. Also, the increase in temperature during the rabi season in north India has affected the country's wheat production and forced us to import to maintain the buffer stock. Hence, there is a need to address the whole issue of climate change and its ill-effects on Indian agriculture in totality so as to mitigate the same through adaptive techniques against the global warming on war-footing.

I am happy to understand that a good piece of work is carried on 'Climate change and its effects on Agriculture' in various parts of the Country at regional scale under the All India Co-ordinated Research Project on Agrometeorology, CRIDA, ICAR, Government of India. Out of the results emerged from the project work on climate change, a publication entitled "Climate change and Agriculture over India" has been brought out in an abridged form for the benefit of researchers, teachers, students and finally farmers to whom the material is intended to. I take this opportunity to congratulate all the contributors who are all involved in preparation of this manuscript, in particular Dr. G.G.S.N Rao, Project Co-ordinator (Ag. Met.) for providing dynamic leadership, in bringing out this publication. Probably, this is the first of its kind in this direction at the regional scale. I also understand that this publication is brought out for release in connection with the International Symposium on Agrometeorology and Food Security, being held at CRIDA, Hyderabad during 18-21, February, 2008. I hope the publication will be of immense use for planners at the national/state level to chalk out various adaptive techniques against the ill-effects of climate change/variability/weather extremes.

I wish the deliberations of the International Symposium a grand success.

New Delhi
08.02.2008

Anil Kumar Singh
Deputy Director General (NRM)

PREFACE

The monsoon behaviour in 2007 over Kerala was totally different to that of previous years and heavy rains were noticed from June to September, leading to floods in low lying areas. The Paddy area was damaged in the Alappuzha belt of Kuttanad in Kharif 2007 due to floods. The length of rainy season was also extended, leading to delay in "puncha" sowing (second crop). No rains were noticed after "puncha" sowing since 24th November onwards. It revealed that prolonged flooded rains during the monsoon, followed by no rains during the "puncha crop" led to low paddy yield during 2007 – 08 in Kuttanad, which is one of the rice bowls of Kerala. In contrast, severe summer droughts were noticed in 1983 and 2004 during which the surface water resources became scarce due to hydrological drought and the State's economy was hit very badly. Such abnormal weather phenomena could be attributed to global warming or as a part of natural climate variability/change. The year 1987 was the warmest year over Kerala and the decade 1981-1990 experienced more number of droughts. Deforestation, loss of wetlands, shift in cultivable area from foodgrains to non-foodgrains, drying of ponds and wells, indiscriminate sand mining and depletion of groundwater are the major changes noted over Kerala. The Western Ghats is one of the 25 hot spots of biodiversity in the World. Most of the biomes seem to be highly vulnerable to the projected change in climate in a relatively short span of 50 years. Such extreme weather events are not uncommon in other States too across the Country. Temperature rise and variability in rainfall in recent years might be one of the potent factors for stagnation in agricultural production over various states. The Indian foodgrains production also revolves around 210-215 million tonnes since last several years due to the effect of weather abnormalities like droughts and floods and cold and heat waves despite the advanced technology.

The scientists involved in climate change research indicate that climate change or variability may lead to more frequent weather related disasters in the form of floods, droughts, landslides and sea level rise. In a tiny State like Kerala, which falls under the humid tropics, it is indicated that the Southwest monsoon rainfall is likely to decline, surface air temperature and its range are likely to increase along the highranges of the Western Ghats. Under such circumstances, there is threat to thermo-sensitive crops like black pepper, cardamom, tea, coffee and cashew. Therefore, there is a need to formulate climate change risk management strategies to minimise the ill effects of climate change on war-footing.

I understand that the ICAR has brought out a publication entitled "Climate Change and Agriculture over India" in collaboration with the Kerala Agricultural University in an abridged form out of the results emerged at various centres under the AICRP on Agrometeorology. I am happy to understand that Dr.GSLHV Prasada Rao and his team, Department of Agricultural Meteorology were actively involved in the editorial work of the publication. I hope the material will be read immensely and used by the researchers, teachers, students and planners. I take this opportunity to congratulate all the scientists who contributed material for bringing out this valuable publication. I also understand that this publication is brought out for release in connection with the International Symposium on Agrometeorology and Food Security, being held at CRIDA, Hyderabad during 18-21, February, 2008.

I wish the deliberations of the International Symposium a grand success

Vellanikkara
09.02.2008

K.R.Viswambharan, I.A.S
Vice Chancellor

EDITORS' PREFACE

Increase in aerosols (atmospheric pollutants) due to emission of greenhouse gases including black carbon and burning of fossil fuels, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), Ozone depletion and UV-B filtered radiation, eruption of volcanoes, "human hand" in deforestation, forest fires and loss of wetlands may be causal factors for weather extremes. The loss of forest cover which normally intercept rainfall and allow it to be absorbed by the soil, causes precipitation to reach across the land, eroding top soil, causing floods and droughts. Paradoxically, the lack of trees also exacerbates drought in dry years by attaining soil to dry out more quickly. Among the greenhouse gases, CO₂ is the predominant gas leading to global warming as it traps long wave radiation and emit back to the Earth surface. The global warming is nothing but increase of surface temperature due to emission of greenhouse gases, thereby increasing global atmospheric temperature over a long period of time. Such changes in surface air temperature and rainfall over a long period of time is known as climate change. If these parameters show year-to-year variations or cyclic trend, it is known as climate variability. The projected temperature rise, average of various models, is estimated as around 3°C by the end of 2100 A.D. Similar is the case over India also. Probably, the climate scientists pushed the various political Governments across the World to understand the ill-effects of climate change on various sectors linked to the society under the umbrella of Intergovernmental Panel on Climate Change (IPCC). This year's Nobel Peace Prize had gone to IPCC and Mr. Al Gore, former Vice-President of US at his individual capacity who made striking features on awareness programme of climate change and its effects across the World.

The Indian economy is mostly agrarian based and depends on onset of monsoon and its further behaviour. The year 2002 was a classical example to show how Indian foodgrains production depends on rainfall of July and it was declared as the all-India drought, as the rainfall deficiency was 19% against the long period average of the country and 29% of area was affected due to drought. The All-India drought is defined as the drought year when the rainfall deficiency for the Country as a whole is more than 10% of normal and more than 20% of the Country's area is affected by drought conditions. The kharif foodgrains production was adversely affected by a whopping fall of 19.1% due to all – India

drought during monsoon 2002. Similar was the case during all-India drought in 1979 and 1987. It reveals that the occurrence of droughts and floods during Southwest monsoon across the Country affects foodgrains production to a greater extent. It is one of the reasons that the foodgrains production is not in tune with plan estimates and likely to touch only a maximum of 260 million tonnes by 2020 at the present rate though it is projected as 400 million tonnes to declare India as one of the developed countries. On regional scale also, the adverse affect on foodgrains production is significant due to occurrence of droughts and floods. They devastated rice and other crops in Andhra Pradesh and 40% cereal production was affected in Karnataka in 2006. Similar was the case in 2007, which can be declared as a flood year in India as several states were adversely affected due to occurrence of floods in monsoon months.

If sea level increases as projected, the coastal areas of many Nations which are thickly populated will be in peril and for the existing population, the safe drinking water will be a great problem. Therefore, there should be a determined effort from developed and developing countries to make industrialization environment-friendly by reducing greenhouse gases pumping into the atmosphere. In the same fashion, awareness programmes on climate change and its effects on various sectors viz., agriculture, health, infrastructure, water, forestry, fisheries, land and ocean biodiversity, sea level and the role played by human interventions in climate change need to be taken up on priority. In the process, lifestyles of people should also be changed so as not to harm earth-atmosphere continuum by pumping greenhouse gases and CFCs into the atmosphere.

In the above context, it is felt that there is a need to understand the effect of regional climate on the agricultural sector so that adaptation techniques can be evolved for mitigation of ill-effects of climate change. In this direction, a good effort is made by the ICAR and SAUs under the All India Co-ordinated Project on Agrometeorology, (AICRPAM), CRIDA, Hyderabad and Network Project on Climate Change (NPCC). On the initiatives of the Project Co-ordinator (AICRPAM), a publication in the form of textbook on "Climate Change and Agriculture over India" has been brought out based on the work done at various centres in different agroclimatic zones. Altogether, the textbook contains fifteen chapters with 288 pages.

The impact of weather extremes like floods and droughts on Indian foodgrain production was highlighted along with the impacts of global warming across the World on the agricultural sector in general in the first chapter. It revealed that weather extremes are the inhibiting factors for stagnation in the Indian foodgrains production. The second chapter deals with the regional climate change impact across the country on various sectors linked to the society. It stressed on weather tuned farming to enhance the agricultural productivity along with the effective management of biophysical resources for sustenance of agricultural systems under rainfed conditions against the climate change/variability. The response of plantation crops in the humid tropics over Kerala to climate variability is highlighted in third chapter. Rise in temperature range and decline in rainfall,

especially across the highranges of the Western Ghats, in addition to the deforestation are likely to be a threat to the thermo - sensitive crops like cardamom, coffee, tea and black pepper. The decline in area and production of cashew are to be understood in relation to climate change/variability as it is highly sensitive to weather aberrations during its reproductive phase. The fourth chapter deals with effects of climate change on agriculture over Tamil Nadu. Temperature rise during kharif may not be favourable while conducive during rabi, which will reflect on paddy yields over Tamil Nadu. Unlike temperature trends, rainfall trends differ differently across the State of Tamil Nadu. The change in cropping systems in tune to climate variability over Karnataka is brought out in detail in chapters five and six. Rainfall shifts and decline in temperature already resulted to a change in cropping systems. Frequent occurrence of droughts led to development of drought tolerant varieties to sustain agricultural production over the State. Unlike in other states, forest cover in Karnataka is increasing which is definitely a positive sign. Temperature rise is projected at Sholapur over Maharashtra in both kharif and rabi seasons. The cropping systems in tune to the climate variability at Sholapur are brought out in detail in chapter seven. In the eighth chapter the impact of climate change over Chhattisgarh is highlighted. Decline in rainfall and increase in temperature are projected in ensuing decades. These trends are harmful to the rice crop under irrigated as well as unirrigated conditions. Decrease in maximum temperature in March also helped the farmers to take up two crops of potato during winter season after rice. Rainfall trends over Gujarat is variable spatially within the State while temperature showed increasing trend. Increase in temperature appears to be detrimental to wheat yield which is brought out clearly in chapter ten. Rainfall pattern in Madhya Pradesh showed latitudinal decrease and longitudinal increase while no such trends in the case of temperature. Altitudinal variations in the distribution of medicinal plants over Madhya Pradesh are clearly brought out in chapter eleven in addition to climate change impact on rainfed agro-ecosystem. Rainfall and temperature increase in Bihar and eastern Uttar Pradesh are the projected trends. The mitigation strategies against the above trends are suggested in chapter twelve. The impact of climate change on agriculture over West Bengal is dealt in chapter thirteen. It is suggested to have suitable contingent crop planning for different situations to tackle the weather extremes. Increase in temperature is also projected in ensuing decades over the Gangetic West Bengal. Rise in temperature range and decline in minimum temperature are the projections over Orissa. The frequency of cyclones is likely to increase as per the global projections. Tamil Nadu, Andhra Pradesh, Orissa and West Bengal along the Eastcoast are prone to cyclones. The ill-effects of weather extremes on crop production over Orissa are brought out in chapter nine. The impact of climate change on agriculture over Haryana is dealt in chapter fourteen while Punjab in the last chapter. Due to increase in temperature during the reproductive phase it has negative impact on wheat production over Haryana and Punjab. The projections in temperature rise may likely reduce the area under wheat crop in both the States as the models predict decline in wheat production with increase in temperature. Similar is true in the case of wheat production over Gujarat. Though temperature rise is projected in ensuing decades such trends

are missing in case of rainfall in its spatial distribution in different agroclimatic regions.

The area under agriculture is diminishing over a period of time. The crop productivity is stagnated since last one decade. It is attributed to frequent occurrence of weather extremes like droughts, floods, heat and cold waves. Probably, it is one of the reasons that increase in Indian foodgrains production is not in tune with plan estimate. At the regional scale, temperature rise is projected and such trend in rainfall is missing in several states. The projected increase in maximum temperature during the reproductive phase is a threat to the wheat production over the wheat growing regions. Similarly, increase in temperature range across the highranges of the Western Ghats may be a threat to thermo-sensitive crops like cardamom, coffee, cocoa and black pepper. While deforestation is alarming over various states, there is a positive sign over Karnataka as forest cover is increasing. Hence, there is a need to develop adaptation technologies against the climate change/variability.

The Editors wish to thank all the contributors who have done a commendable job in compiling the information in a short period time. The results obtained through the studies under the aegis of AICRPAM are significant and may formulate guidelines for future agricultural planning at various regions of the country. The Editors wish to express their sincere gratitude to the Indian Council of Agricultural Research for funding the publication through AICRPAM. The Editors are also thankful to the authorities of Kerala Agricultural University in bringing this publication through its AICRPAM Research Centre at Thrissur in a record time.

Editors


MESSAGE

There are strong evidences over the past few decades that significant changes in climate are taking place world wide as a result of enhanced human activities and indiscriminate use of fossil fuels. Efforts are on by many nations to mitigate the challenges posed by the global warming and the food security especially of developing countries is at stake. Government of India through its Research Organizations like ICAR is making efforts to minimise the impact of climate change from its various Coordinated Research Programs, viz., All India Coordinated Research Project on Agrometeorology, Network Program on Climate Change and All India Coordinated Research Project for Dryland Agriculture.

I am very much pleased to know the research work carried out by the Coordinating Unit and Research Centres of AICRPAM in the field of climate change and their impact on agricultural production. I am also happy to see the excellent results emanated from the studies conducted by the Cooperating Centres through this publication. The efforts made by Thrissur centre and Coordinating Unit of AICRPAM are appreciable in bringing out this valuable publication.

I wish all the authors of this publication more success in their future research endeavours.

Hyderabad
08-02-2008


Y.S. Ramakrishna
Director, CRIDA

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