CLIMATE CHANGE, ITS IMPACT ON WATER RESOURCES AND ADAPTATION STRATEGIES

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ABSRACT

The latest assessment report of the IPCC (Intergovernmental Panel on Climate Change), projects that global average temperatures in 2100 will be between 1.8 – 4.0^{0}C higher than the 1980 – 2000 average. Sea levels are projected to rise 0.18 – 0.59 m. More frequent and intense extreme weather events are expected. Recent global climate analysis has indicated that the climate change is likely to change stream flow volume, as well as the temporal distribution throughout the year over Asian region, imposing significant stress on the water resources in the region.

The vulnerability of the Indian subcontinent to the impact of changing climate is of vital importance because the major impact of climate change in this continent would be on the hydrology, affecting water resources and agricultural economy. However, very little work has been carried out in India on the impact of climate change on hydrology. The major river systems of the Indian subcontinent, namely Brahmaputra, Ganga and Indus which originate in the Himalayas, are expected to be vulnerable to climate change because of substantial contribution from snow and glaciers into these river systems. It is understood that the global warming and its impact on the hydrological cycle and the nature of hydrological events would pose an additional threat to the Himalayan region.

The present paper highlights the climate change and its impacts on the water resources with a special emphasis on floods and droughts disasters. IPCC projections and evidence from recent observations in India are also discussed in the paper. NIH has initiated a few studies to investigate the impact of climate change on water resources. In this regard, some of the Himalayan and Peninsular rivers sub-basins are selected for carrying out these studies. Conceptual models are calibrated and validated for the selected sub-basins and used to simulate the hydrological response of the basin considering the changed climatic scenarios. The outcomes of these studies are briefly presented in the paper. Climate change is likely to affect the temporal and spatial variability of the available water. The paper also highlights the various studies need to be carried out for addressing the important issues involved in flood and drought management under changed climatic conditions. The findings of such studies would be very much useful for evolving the adaptation strategies in order to combat the future challenges in water sector due to climate change particularly in dealing with the disaster management related to water in most effective manner.

HYDROMETEOROLOGICAL NATURAL DISASTERS OVER SOUTH ASIA AND DEVELOPMENT OF EARLY ATOMSPHERE-OCEAN WARNING SYSTEMS IN THE CONTEXT OF EMERGING CLIMATE CHANGE SCENARIO

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ABSTARCT

There have been recently some definitions of natural disasters such as (i) a serious disruption of functioning of society causing widespread human, material or environmental losses which exceed the capacity of society to cops using only its own resources, (ii) a temporary event triggered by natural hazard that overwhelms local response capacity and seriously affect the social and economic development of a region (iii) disaster as an interface between an extreme physical environment and vulnerable human population. Over 80% of the natural disasters over South Asia are caused by extreme hydro-meteorological events interacting with landform, geological and physical environment

Disaster profile of South Asia: Hydro-meteorological includes disasters related to tropical cyclones and storm surges, floods, droughts, phenomenally heavy monsoon rainfalls, forest fires, extreme and persistent heat or cold waves, avalanches and land slides in mountainous regions etc. Impacts of such disastrous hydro-meteorological disasters are both direct and indirect or short-lived as well as long-lived. Improved use of weather and climate information and forecasts have the potential to reduce risks of such disasters if proper early warning systems are in operation at national and international levels. Many lessons were learnt during the implementation of the international programme on the Decade of Natural Disasters. However, losses due to disasters have been increasing in the last two decades as development efforts have intensified and use of unsafe habitats have become more and more unsafe as disasters strike these regions repeatedly.

Meteorology has played a role in safeguarding societies from the wrath of hydro-meteorological natural disasters. In fact the establishment of IMD came as a result of a severe cyclone striking Kolkata in 1865 which resulted in heavy losses to trade, commerce and shipping. The developments in IMD during 1875-1950 resulted in upgrading of storm warning services, flood warnings and heavy rainfall warnings as well as warnings against slowly evolving drought situation, land slides, severe local thunderstorms. Avalanche warnings became of special importance since 1975 and a special agency SASE has been established by the Government of India for this purpose. Similarly other countries of South Asia have developed respective disaster early warning system.

The progress of early warning system depended on monitoring of atmospheric-ocean environment and research on such events. As weather prediction developed by supplicated dynamical modeling, such forecast began to be used more effectively since

1950s but more specifically since 1980s. There are uncertainties in prediction of high impact weather events which leads to hydromet disasters. However, there is a hope that a conesus among the models or an ensemble based decision system is superior to empirical methodologies of the past. Recent development in this direction are discussed. Monitoring of atmosphere-ocean environment needs sophisticated modern observational systems. Technological developments in this direction, since 1950s, are traced in the paper and the present status of the atmosphere-ocean observing system and its continuous modernization is emphasized.

Climate prediction of interannual to decadal scales is the new frontier. Earth Science System Partnership and coordinated Environmental Observational Programme and Systems are likely to help in the emergence of seamless prediction of earth system and consequently improve Disaster Warnings. The paper discusses about the work of special agencies like India's National Disaster Management Authority, the National Institute of Disaster Management and the SARC Disaster Management Centre, New Delhi with the support from National Weather and Oceanographic Services, have roles to reduce the risks associated with hydro-meteorological Natural Disasters. The paper also stresses upon active participation of print and electronic media and considers it as essential for communicating the early warnings to threatened population. Other steps needed are to determine optimal risk reduction strategies in the face of uncertain weather. Climate thresholds in the context of climate change scenarios add other dimensions and these must be recognized. Research is needed to reduce the knowledge gap and societies have to be kept informed about the progress. The paper ends with the note that the way to continued progress in risk reduction of hydro-meteorological disaster rests with better monitoring, better modeling efforts and better communication of threat perception in a probabilistic manner for which public awareness is to be progressively promoted.

IMPACT OF CLIMATE CHANGES ON WATER RESOURCES

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ABSTRACT

A very exhaustive study was conducted as part of the National Communication (NATCOM) project undertaken by the Ministry of Environment and Forests, Government of India to quantify the impact of the climate change on the water resources of India using a hydrological model. The study uses the HadRM2 daily weather data to determine the control (present) and GHG (future) water availability in space and time. A distributed hydrological model namely Soil and Water Assessment Tool (SWAT) has been used on major river basins of the country. The framework predicts the impact of climate change on the water resources with the assumption that the land use shall not change over time and any manmade changes like dams, diversions, etc. have not been incorporated. Simulation of 12 river major basins of the country have been conducted, with 20 years belonging to control (present) and the remaining 20 years for GHG (future) climate scenario. Each river basin has been subdivided into reasonable sized sub-basins so as to account for spatial variability. Quantification of climate change impact has been done through the SWAT hydrological model. It has been observed that the impacts of climate change are not uniform over the country and are varying across the river basins as well as across sub-basins. The initial analysis has revealed that the GHG scenario may deteriorate the conditions in terms of severity of droughts and intensity of floods in various parts of the country and that there is a general reduction in the quantity of the available runoff under the GHG scenario. This paper presents the analyses of two sample river basins with respect to drought and floods.

CLIMATE CHANGE AND INDIA - A RESPONSE STRATEGY

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Abstract
Climate and weather are entwined with the human system and its functioning. Human physiology can handle substantial variation in weather and climate. Any changes in weather or climate within a short span of time upsets the systems making it susceptible to diseases. The impacts are likely to exacerbate with impending projections of climate change. Climate change concerns in India include the rising temperatures, the projected variable pattern of precipitations, its intensity and frequency, and the enhanced incidences and intensity of extreme events such as cyclones, flash heavy rains and consequent floods. All these have direct or indirect repercussions on health which may range from changed distribution of vector borne diseases, increased virulence of some water borne diseases, enhanced incidences of malnutrition or pulmonary failures due to extreme temperatures amongst others. All these need to be tackled through the enhanced and retrofitted public health system that takes factors in climate change. This paper reviews the climate change concerns for India and the consequent health impacts and suggests steps towards adaptation through enhanced public health services measures.

CHANGES IN FREQUENCY AND INTENSITY OF TROPICAL CYCLONES OVER INDIAN SEASIN A WARMING ENVIRONMENT

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Abstract

The climate system is a complex, interactive system consisting of the atmosphere, hydrosphere, biosphere, cryosphere, lithosphere and outer space. The fourth assessment report (AS4) of Intergovernmental Panel for Climate Change (IPCC) has clearly indicated the change of the temperature both over the land and ocean. As a result, the impact of disasters such as tropical cyclones, drought, flood and extreme temperature events etc. have an increasing trend with time. The extreme weather event like tropical cyclones varies abruptly from year to year in terms of frequency and intensity over all the cyclone basins. Indian seas comprised of Bay of Bengal and Arabian Sea is quite different than any other regions of the world as per the genesis and movements of the cyclonic storms are concerned. Also, the uniqueness of the Indian region is mainly characterized to two cyclone seasons such as pre-monsoon (April-May) and postmonsoon (October-December) cyclones.

The present study is to evaluate the changes in frequency and intensities of cyclonic storms over Indian seas with the ongoing global warming processes. For this purpose, 118 years (1891-2008) of tropical cyclone data as obtained from the India Meteorological Department (IMD) is analyzed. The Hardly center Sea Surface Temperature (SST) data for the above mentioned period is analyzed to study its impact on the frequency and intensity of the tropical cyclones. The analysis result shows an increasing trend for the Bay of Bengal cyclones, however a sharp increasing trend is observed for severe cyclonic storms, as the SST of whole Bay is increased by 0.4 deg C in both pre and post monsoon seasons. The Arabian Sea cyclones are also showing increasing trend in post- monsoon seasons, however the pre-monsoon systems shows decreasing trend, as the Arabian Sea is warmer in post- monsoon compared to premonsoon season.

A HIGH RESOLUTION MODELLING STUDY OF FUTURE CLIMATE CHANGE SCENARIO OVER ASIA

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ABSTARCT

A recent report of the Intergovernmental Panel on Climate Change (IPCC) has clearly mentioned that the Earth's Climate is changing. In order to show the evidences of climate change, several studies have chosen temperature and precipitation as primary parameter. The IPCC has also reported that the global average temperature has increased by 0.6 ± 0.2^0C over the late 20th century. While annual precipitation over land has continued to increase in the middle and high latitudes of the northern hemisphere (very likely to be 0.5 to 1% per decade), except over Eastern Asia. Whereas over the sub-tropic zones (10^0N-30^0N), the land surface precipitation decreases on an average (0.3%/ per decade), although this has shown a sign of recovery in recent years. An increase in concentrations of green houses gases (CO_2 etc.) and aerosols in atmosphere play major role in climate change. IPCC also has reported that atmospheric concentration of CO_2 has been increased from 280ppm in 1750 to 367ppm in 1999. The Carbon cycle model has projected the concentration of atmospheric CO_2 may be within the range from 540ppm to 970ppm (SRES Scenarios) by 2100.

The Dynamical downscaling techniques has been used to get the current climate change information using a regional climate (MM5) model (Pennsylvania state University / National Centre for Atmospheric Research meso-scale model) nested within the Max-Planck Institute for Meteorology Model and Data Group's Atmosphere - Ocean General Circulation Model (AOGCM) ECHAM-4. The MM5 simulated the surface air temperature and precipitation have been studied in detail over the East Asia and its 4 sub-regions namely (1) North China, (2) Central China, (3) Korea and (4) Japan. The MM5 results are compared with ECHAM-4 global model and observed (CRU) data sets. Results indicate that ECHAM-4 model shows cold biases especially over the North China and the Central China as compared with CRU observation. The cold biases are observed as highest in spring and winter with -3.6^0 and -2.9^0 over the North China and -3.7^0 and -3.6^0 over the Central China. Simulations of future climate change over the East Asia multi decadal time scales have been also studied in detail. Changes in temperature and precipitation on inter-annual and decadal time scales are discussed from 2001-2100 (100 years) with respect to 2001-2010 (recent ten years) under the forcing from the IPCC SRES (Special Report on Emission Scenario) A2 scenario. Results show that under A2 forcing scenario, the East Asian region under goes substantial warming in the range of 0.3 to 5.5^0C during 2001-2100. The simulated precipitation shows that there would be an increase in the rate of annual precipitation 0.07mm/day in the year of 2100. In other words, the precipitation increases by 2.6% annually in comparison with the current climate (2000s) rate of 2.68mm/day.

MULTIPLE SATELLITE INPUTS FOR DISASTROUS RAINFALL VIGILANCE: HISTORICAL EVENT OF MUMBAI

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ABSTARCT

Now a day, excessive rainfall events are observed frequently at various places over the Indian region. Due to occurrence off such unusual phenomenon there is demand from public for accurate short-range forecast to overcome the grievances likely to arise. As we know that major part of Indian land mass is prone to several natural disasters with east and west coast being affected by super cyclonic storms, deep depressions and severe off shore vortices. In the recent years the focus of disaster management community is increasingly moving on to more effective utilization of emerging technologies such as satellite remote sensing enabling for monitoring potential impacts.

It is seen that no atmospheric model could give correct forecast for historical excessive rainfall event at Santacruz on 26 July 2005. The reason is that various atmospheric models could not get very high resolution conventional data (~10 Km resolution) as an input. Obviously It is true because at such a high resolution we don't have the observatories and it is not possible also. Hence in the present study an integrated approach of multiple satellites such as INSAT, METEOSAT, TRMM and IRS-P4 has been made for monitoring typical variations in visible/infrared imageries, deep convection, geophysical parameters and precipitation rates at high resolution at various stages of development/dissipation of the disastrous system which formed over Mumbai on 26 July 2005. Atmospheric conditions prevailing one day before and one day after the occurrence of this system are studied to monitor drastic variations generated in the meteorological parameters during complete life cycle of this system. It is revealed from the satellite synergy that on 26 July integrated water vapor (60 mm), cloud liquid water content (0.3 mm), deep convection (85 W/m²) and precipitation rates (50 mm/hr) were of maximum value in the region of vortex when TRMM satellite was passing over Mumbai. It is significant to note that development and enhancement of vortex over off shore trough was only available on 26 July. Due to this reason satellite derived parameters observed on 25th and 27th July showed less magnitude as compared to 26 July. Variations in meteorological parameters produced by input of satellite synergy at each synoptic hour observations were recorded for getting signatures of extremely heavy rainfall over different parts of Mumbai. Even OLR values were computed at each pixel level to recognize the aerial extent of major convection. Our results obtained from integrated approach of multiple satellites certainly formulate effective strategy to minimize public grievances especially during peak development of disastrous system.

ASSESSING THE VULNERABILITY OF AGRICULTURAL PRODUCTIVITY *VIS-À-VIS* WINTER SEASON EXTREME EVENTS IN SEMI-ARID REGION OF INDIA

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Climatic variability is basically a micro-regional climatic phenomenon having some direct impacts on people and environment. Extreme events are induced by this variability in micro-regional climate. Climatic **ABSTARCT**

variability poses a serious threat to every part of the world especially Asian region facing the challenge of ensuring food and nutritional security to the growing population. Besides ecological, technological and socioeconomic drivers, climate change / variability associated frequent extreme weather events has become an important determinant of agricultural productivity in this region. In this study, an attempt has been made to (a) quantify the recent winter season extreme events and (b) agricultural productivity of important *Rabi* crops in Haryana representing semi-arid region of India. Since 1995 onwards in the region (the year IPCC has identified after which the frequency of extreme weather phenomena has increased; FAR-2007) the relevant climatological data on the abnormal temperatures- high as well low, frost, intense fog and heavy precipitation etc. and agricultural productivity during the rabi season were collected and analyzed. During the winter season (October to March), the appreciably below normal night and day time temperature events ranged between 6 to 34 and 2 to 51 days, respectively. The maximum numbers of events (34) of appreciably below normal night temperature were observed during 1998-99 and 51 appreciably below normal day temperature during 1997-98. The below average trend showed increasing and decreasing tendency in minimum and maximum temperature, respectively. While working on rabi season's rainfall and associated weather systems developed vis-à-vis global teleconnections, the above average (50.0 mm) rainfall was recorded during the crop seasons of 1995-96, 1996-97, 1997-98, 2004-05 and 2006-07. The deficient rainfall seasons were 1999-00 (19.0 mm), 2000-01 (No rain) and 2007-08 (8.0 mm). The seasonal rainfall's associated weather system i.e. Western Disturbances ranged from 15 to 41. The frequency of these weather systems reached over the region ranged 1 to 12.

Simple extremes, such as higher maximum land temperatures, intense foggy days and more intense precipitation, are projected to be very likely. The importance of extreme events and regional climate threshold exceedance for various field crops need to be further established. The impact of intense foggy events and high temperature during winter season (October to March) on wheat productivity during 1995 to 2008 in Haryana representing semi-arid region of India was studied. Interestingly, an increasing trend (@ 1.3 day/season) in occurrence of fog events was seen. The intense foggy events reduced photosynthetically active radiation (PAR) availability to crops and thus, reduced the grain yield. Exceptionally high temperature during maturation and ripening (January to March) phase also proved detrimental for mustard and wheat production due to terminal stress.. The intermittent higher than the normal temperatures regimes with insufficient rainfall

caused forced crop maturity in these crops by curtailing the seed/grain development phase which resulted in shriveling of grain with poor seed size affecting the test weight and final productivity. The reduction in mustard and wheat yield (q/ha) was reported around 25 to 55 and 10 to 15 %, respectively due to sensitivity of crucial phenophases of crops to the abnormal and untimely weather extremes. While developing multiple regression equations using foggy events and terminal heat stress, about 60 to 70 % variations in productivity of these crops may be explained by these two extreme weather events. It may be ascertained that these amplified simple extremes could lead to extreme weather events like sustenance and intense foggy events leading to radiation stress and terminal heat stress causing significant decrease in mustard and wheat productivity in the region. This impact is very critical for India which has more than 70 per cent of its population relying on agriculture directly or indirectly. Therefore, comprehensive and collaborative research using agrometeorological components including crop-climate modeling system which is capable of simulating the impact of threshold exceedance, occurrence of extreme events/changes in the mean and variability of climate, and adaptive measures in developing economies. It must be stressed for sustainable and nutritional food security by developing crop varieties tolerant to temperature thresholds and extremes and fine tuning of improved and efficient crop management practices and ultimate outreach through weather based farm advisory services to farming community.

CLIMATE CHANGE: TO LEARN TO ADAPT IS THE BEST POLICY

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ABSTARCT

Climate change is affecting hundreds of millions and in the next 20 years their number will likely more than double, according to latest estimates. This would make it the greatest emerging humanitarian challenge of our time. In its Fourth Assessment Report, the IPCC found that weather patterns have become more extreme, with more frequent and more intense rainfall events and more intense heat waves and prolonged droughts. In addition to the increased severity of weather events, the sheer number of weather-related disasters (storms, hurricanes, floods, heat waves, droughts) has more than doubled over the last 20 years. Those most vulnerable live in the semi-arid dry land belt countries, sub-Saharan Africa, South and Southeast Asia, Latin America and the small island developing states.

In South and Southeast Asia, the most affected countries include India, Pakistan, Bangladesh, southern and eastern China, Myanmar, Vietnam, Philippines and Indonesia. The only way to reduce the present human impact is through adaptation. Despite the lack of funding, some cases of successful adaptation do provide a glimmer of hope.

Bangladesh is one such example. Cyclone Sidr, which struck the nation in 2007, demonstrates how well adaptation and prevention efforts can pay off. Disaster preparation measures, such as early warning systems and storm-proof houses, helped minimise damage and destruction there. Cyclone Sidr's death toll of 3,400 and economic damages of $1.6 billion compares favourably with Cyclone Nargis that hit Myanmar only last year leading to a death toll close to 1.5 lakh and economic losses of $4 billion. Integrating strategies between adaptation, mitigation, development and disaster risk reduction is the need of the hour. Mechanisms and sanctions, including a globally accepted solution on taxing CO2, should also be pursued in right earnest. But such a pricing system must not add to burden of the poor.

FOOD SECURITY IN CLIMATE INDUCED STRESSED SITUATIONS

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ABSTARCT

Eastern Gangetic Belt is among the most bountiful regions with plentiful of natural resources but large parts are also poverty- stricken and flood affected. In a region where agriculture on small holding is predominant, floods have caused extreme devastation. With the changes in climatic conditions the nature of floods- rainfall pattern, flash floods, flood timing, water logging etc.- have also changed causing food and livelihood insecurity.

Recent researches have shown that the climate change on A2 and B1 scenarios is projected to influence river flow patterns through changes in the amount and timing of rain fall in Rohin river basin. The major changes are in form of more rainfall in monsoon months and lesser rains in winter season. It is important that the farmers are able to adapt to such changes for their livelihood and food securities.

The small and marginal farmers of Rohin river basin in the Trans Saryu region in eastern Uttar Pradesh have adapted to such stressed situation through locally appropriate agricultural interventions. The strategies like cropping cycle (time and space) management, adoption of flood resilient varieties, integration of farm sub-systems and off farm aspects, value addition and evolving a flood prone agricultural extension mechanisms have been proved quite effective in dealing with floods. The strengthening of environmental (natural resource management, drainage, water etc.) and social (social capital, gender, information, good and services, migration abilities etc.) assets have helped in agriculture related interventions and the farmers to adapt and mitigate the losses.

Efforts will have to be made towards necessary policy support for developing appropriate crop varieties, farming systems and development- disaster management linkages at local level.

EMPOWERING COMMUNITIES TO UNDERSTAND CLIMATE CHANGE

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Abstract

The paper seeks to approach how development practitioners and local communities can work in risk prone areas where disaster vulnerable populations are subject to climate change. The paper will focus on how civil society and government can go beyond the policy and demonstrate practical and sustainable models to engage communities to prepare and mitigate climate change, especially in areas where these are linked to future disaster scenarios.

It is now acknowledged that some of the world's poorest people live in regions which are disaster prone and highly subject to the changing course of climate. There is adequate documentary evidence of this and while policy frameworks have been developed, the community engagement on the ground is yet to find a voice in these legislations. Given this situation, civil society organizations working with disaster vulnerable populations are looking beyond conventional means of disaster preparedness and risk reduction. With this is the added threat of climate change and the yet to be disseminated key issues as to how these are to be managed and adaptation.

The paper therefore attempts to propose a model for community based climate change empowerment and management, combining a theoretical base along with a case study from Indonesia, a country under real threat since the Tsunami in 2004. It is hoped that this will be a useful and key document for future understanding of how climate change issues for both vulnerable communities and policy makers can come together to manage and adapt with this impending phenomenon.

IMPLICATIONS OF CLIMATE CHANGE ON HYDROELECTRIC POTENTIAL OF SATLUJ RIVER, HIMACHAL PRADESH, INDIA

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Abstract

The global, regional and local environment is changing due to many kind of anthropogenic activities such as green house gas emission, change in land use pattern, deforestation etc. The collective effects of such environmental changes result into climate change. The global atmospheric concentration of $C0_2$ and other green house gases have dramatically increased over the previous century. The latest report of Intergovernmental Panel on Climate Change (IPCC, 2007), an international body of over 3000 experts, projects that the global mean temperature may increase between 1.8°C to 4°C by 2100. The increased intensity of climate change in last 50 years is in concurrence with the significant effect on hydrology and water resources of whole India. It will also badly affect the water regime of the Himalayan region. The discharge in the Himalayan River generally consists of two parts, one which is derived from melting of glaciers and another resulting from the monsoonal rainfall in catchment areas. The discharges derived from the melting of snow make the rivers perennial. The excessive melting of glaciers, due to climate change may increase river flow for next 30 or 40 years and may subsequently boost power generation in these Himalayan Rivers. On the contrary if we look at the future prospect, the fast melting of glaciers would lead to decrease in snow cover and subsequently decrease in run-off rate of all rivers. The perennial rivers could be changed to seasonal streams which results in water scarcity. Satluj River in Himachal Pradesh is an important source of hydel power generation in northern India. Any change in discharge pattern of river, due to climate change may have profound impacts on huge hydropower potential and also agricultural productivity of this region. After 30 to 40 years from now, when the glacial water flow decline, the energy potential of hydroelectric projects may automatically decrease. This change in water regime may put question mark on energy security of the country. The compilation of data on discharge rate for the previous few years will help us to understand the future situation of water regime in the region and warn us about the future scenario of hydroelectric potential of all the Himalayan Rivers.

CLIMATE CHANGE ADAPTATION: IS IT ALL ABOUT 'GOOD' DEVELOPMENT?

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Abstract

Climate change is no more a distant threat and its impacts are being experienced all over the world. The climate change science and concepts have also been growing at an enormous pace renewing the hope to mitigate the causes and adapt to changing climatic system. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report makes it clear that "adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions"[1] Adaptation emerged as one of the four "building blocks" in the Bali Action Plan at the United Nations Climate Change Conference in Bali in December 2007. The Bali Action Plan emphasized on vulnerability reduction and climate resilient development by integrating adaptation actions into sectoral and national planning.

It has been well recognized that poor countries and communities that have done least to contribute to climate crisis are the worst sufferers and have least capacities to adapt. Most countries that are facing the brunt of climate change rank low in Human Development Index, which combines normalized measures of life expectancy, literacy, educational attainment, and Gross Domestic Product (GDP) per capita. Least developed countries, Small Island Developing States, and Africa have been specifically recognized as vulnerable to climate change. This raises the key question whether "good" development equals adaptation or more is required to avert the climate crisis!

A successful adaptation process will require adequately addressing the underlying causes of vulnerability: this is the role that development has to play[2]. The paper approaches the concept of adaptation by unraveling the development approach that addresses the underlying factors that cause vulnerability. Adaptation 'solutions' cannot be exported to a vulnerable area or community but need to be premised on sustainable development approach that empowers vulnerable communities with adequate capacity and resources to build their resilience to adapt to the changing climate.

COUPLING CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION: EMERGING TRENDS IN SOUTH ASIA

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Abstract

Two thirds of the disasters the South Asian region experiences are of climate related and there have been phenomenal increase in their frequency, severity and unpredictability in the recent times. The societal vulnerabilities are aggravating from stresses on water availability, agriculture and environment. The fourth assessment of Intergovernmental Panel on Climate Change (IPCC) highlights increasing severity and frequency of storms, high rainfalls, floods, drought and heat waves. With climate sensitive agrarian economies, climate change mitigation and adaptation are among the common priorities along with the disaster risk reduction for all the countries such as Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka of South Asian region.

The integration of the climate change mitigation/ adaptation efforts with disaster risk reduction is therefore quite crucial. Although, efforts to bring together stakeholders in climate change and disaster management have begun to create an opportunity for integration, challenges however lie not only in harmonizing diverse institutional structures, distinct sectoral planning & policies etc but also in communication between the communities of practice at global, regional and national levels. The recent years have just seen a beginning of this trend indicating the communities of climate change and disaster management talking to each other and coming closer, the integration however continues to be a challenge especially in South Asian region. The present paper intends capturing the images of such trends from semi-arid regions of India and Pakistan; flood-plains of Bangladesh and Nepal; and Coastal regions of India and Sri Lanka.

IMPACTS OF CLIMATE CHANGE IN INDIA

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Abstract

It is evident that climate change is a silent disaster with enormous damaging potential and causing disastrous implications in the atmosphere. Our survival is threatened more due to human activities contributing to climate change. We need to wake up now and accept "the inconvenient truth" of climate change before it is too late. The human race has to follow the low carbon path of eco-friendly sustainable development for a better future and safer world

Climate change refers to any long-term significant change in the expected patterns of average weather of a specific region or area or zone over an appropriately significant period of time. The factors that determine the climate at a location are the rainfall, sunshine, wind, humidity, and temperature. Climate change may result from events-such as changes in the Earth's orbit around the sun, earth's tilt, El Nino, La Nina, burning fossil fuels, Greenhouse effect, deforestation, urbanization, desertification, volcanic eruption, flood, forest fire, storms, surges ocean circulation etc. Since existence of earth, there have been changes in the climate with well-marked cold and hot periods and all life forms adapted naturally to this change but over the last 150-200 years, the speed of change in climate has increased due to interference with nature by human activities

Climate change is a threat to both mankind and any life form existing on the planet earth! Since the end of the 19th century, the earth's average surface temperature has increased by 0.3-0.6 °C and over the last 40 years, the rise has been 0.2-0.3 °C. Recent years have been the warmest since 1860. It has been observed that there is rise in CO2 concentration in earth's atmosphere from 280ppm in the year 1850 to 379 ppm in the year 2005. The rise in CO2 is having analogous increase in temperature profile and this confirms that global warming is a reality due to increasing CO2 level and other greenhouse gases in the atmosphere. Burning of fossil fuels, such as the energy sector is responsible for about ¾ of the carbon dioxide emissions, 1/5 of the methane emissions and a large quantity of nitrous oxide-all greenhouse gases.

The impacts of climate change in India are all apparent as the water supply in India is getting affected badly with Himalyan glaciers melting at the rate of 10-15mts per year, The Ganges would loose 2/3rd of July-September flow affecting 1/3 rd of India's irrigated land and causing water shortage for 500million people in South Asia. In the current year, the substantial low rainfall, 40% below normal has triggered a drought like situation in entire India and it is alarming with south west monsoon failing badly as a possible consequence of climate change.

The sea level is rising by an average of 3mm per year and due to global warming and sea level rise , the livelihoods and lives of 2.7 million families depending on coastal resources in India are under threat. Storms and cyclones are becoming more frequent and intense with marine life under threat.

Change in average temperature is impacting biodiversity as more flora and fauna enter endangered list now. Possibilities of frequent droughts in Rajasthan, Karnatka, Tamilnadu, Orissa, Chattishgarh, Jharkhandand etc; Floods in Assam, West Bengal, Bihar, Orissa, UP; Cyclone and storms in AP, Tamilnadu & Orissa and submergence of low lying coastal regions are impending disasters as a result of climate change. Climate change will affect agricultural yield directly because of alterations in temperature and rainfall, and indirectly through changes in soil quality, pests, and diseases.

Greater frequency and severity of heat waves and other extreme weather events will affect people living in the urban areas more than those in the rural areas. This is due to the 'heat islands' that develop here owing to the presence of concrete constructions, paved and tarred roads. In the sea, it would create dead zones with no fish.

India accepted Kyoto Protocol in August 2002 with the objective to fulfill requirements of Clean Development Mechanisms (CDMs) It commits the developed countries, including economies in transition to reduce emissions of GHGs by an average of 5.2% below 1990 levels during 2008-2012. This paper seeks to outline the dangerous impacts of climate change occurring in India.

STUDY OF RAINFALL UNDER WARMING CLIMATE FOR DISASTER MANAGEMENT

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Abstract

The Indian Summer Monsoon Rainfall (ISMR) is important for policy makers in various sectors. The variability of ISMR is not only directly linked to agriculture and water resources but its prior information may help in dealing with early warning for disaster management. The short to long range forecasting of rainfall is always helpful to understand and manage rainfall related disasters for a season especially. The long term future planning on disasters like floods and droughts needs high resolution rainfall projections. Due to changing spatial and temporal pattern of rainfall in warming climate, the past and present trends of floods and droughts may alter in warming climate. Any spatial and temporal change in magnitude, intensity and frequency in projected rainfall may affect floods and droughts situation in their prone areas.

The current study on rainfall may help to understand future projection of floods and drought situations. For the purpose, the states from Utter Pradesh (UP) to West Bengal (WB), which is a major part of the Ganga river basin, is selected for the study because these states experience floods and drought almost every years and causing a huge loss of economy and life. The past and present rainfall patterns along with extremes are studied over the regions by using the India Meteorological Department (IMD) gridded rainfall data. The future projected high resolution rainfall by PRECIS (Providing Regional Climates for Impacts Studies) model of Hadley Center, UK is considered. The model simulated rainfall for A2 and B2 scenario is analyzed over from UP to WB. It seems that rainfall especially magnitude will be changed in Bihar and West Bengal in the period of 2071-2100 and will be responsible for change in floods and droughts situation in those states.

GLACIER LAKE MONITORING USING REMOTE SENSING AND GIS IN THE BARALALACHA LA REGION, HIMACHAL HIMALAYA

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Abstract

The high mountainous glacial environment is under threat due to the global climatic change during the first half of the twentieth century. The fast melting of many of the big glaciers gave birth of a large number of glacial lakes. Under the faster rate of snow and glacier melting, possibly caused by the global warming, the accumulation of water in these glacial lakes has been increasing rapidly and putting pressure to their natural damming in most of the cases moraine damming. The increasing water pressure on their damming may result sudden discharge of large volumes of water and debris to down streams giving rise to the Glacial Lake Outburst Flood (GLOF).

In the Himalayan region, it has been observed that the frequency of the occurrence of GLOF events has been increasing in the second half of the twentieth century. Their devastating effect towards the life properties and infrastructures is very well known. The catastrophic GLOF event in the Nepal Himalaya known as the Dig Tsho GLOF in 1985 has destroyed the Namche small hydel project that was built at the cost of US$ 1.5 million approximately.

A study of glacier lake monitoring is being carried out based on the Satellite imagery and GIS as well as field observation in the Baralacha La region at about 16,500 ft high. There are two lakes formed at the outlet of two glaciers in the vicinity. The water coming out from these lakes contributes to the river Yunam which is a tributary of Indus River. One of the lakes (1F4c6_L1) having an area of 1, 01,653.53 sq m in 1989 has swollen to 1, 07,539.18 sq m in 2001 and further increased to 1, 24,670.10 sq m in 2008. The percentage increase of their size is 5.79 %, 15.93% and 22.64% for the years 1989-2001, 2001-2008 and 1989-2008 respectively. The corresponding increases in areas are 5,885.66 sq m during 1989-2001, 17,130.91 sq m during 2001-2008 and 23,016.57 sq m during 1989-2008. This fast increase in the glacier lake can be dangerous, if the moraine that is damming these lakes is not able to withstand the increasing pressure of water in the lakes. This will give rise to the condition of GLOF.

Hence accurate and timely information on the spatial locations and regular monitoring of the glacier lakes' behaviour is helpful to take action before the formation of Glacial Lake into GLOF and prevent the GLOF hazards. Modern information tools such as Remote Sensing and GIS which is also being used in this study could play a lead role in identifying potential risk lakes and monitoring the GLOF events in near real time.

GLOBAL WARMING AND THE CHARACTERISTICS OF WATER UNDER CHANGING CLIMATIC CONDITIONS: A CRITICAL REVIEW

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Abstract

In the case of developing economies, the global warming crisis due to changing climate and its economic consequences presume vital importance in the process of realizing sustainable development. It has been concluded in the Natural Resources Defense Council report that, the global warming may increase the risk of floods, so an efficient and conservative water use will be of paramount importance for future water supply. The functioning of water control institutions in managing natural resource management is being increasingly acknowledged in the perspective of Global Environmental Change (GEC). The main motivation of this paper is to discuss the water management challenges that can handle the threats or stresses like GEC, climate changes, natural disasters like flood, drought or even an extreme climatic event like cyclone. The current paper focuses on the broad area of water management issues such as the major river system of India, condition of ground water resources, the current water utilization, water losses, water under stress, water pollution and increased population & its impact on the problem of scarcity of water. It also focuses on the current water policy, water rights and act, Interstate Water Dispute Act etc. An attempt has been made to illustrate the environmental interface between water and climate. The paper assumed an interdisciplinary approach combining knowledge from environmental sciences with social sciences.

CLIMATE CHANGE: PARANOIA AND PERSPECTIVE

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Abstract

Climate change caused by global warming is one of the most intensely debated topics in today's world. The moot question is whether such changes have occurred in the past and if so, what were the reasons.

Geologists have found clear evidence of climate and sea level changes in the rocks all over the world. For example, the marine Cretaceous sediments in Ariyalur,, Ttamilnadu points to ancient sea level rise; glacial deposits of Talchir, Orissa prove that climate has changed radically.

The age of the earth is ~ 4.6 billion years. Humans appeared only ~ 2 million years ago. The evidence of several warming and cooling cycles of the earth before the appearance of man compels one to look beyond the popular anthropogenic reasons. The records of food, tax and artifacts confirmed the existence of a recent cool period between 1200 and 1850 A.D.

The world is facing a huge problem in terms of pollution. The plastics, industrial effluents, effluents from our cities, chemical fertilizers etc. constitute a range that nature wouldn't have known without the humans. These are primarily anthropogenic but not the climate change.

The variability in sun's activity matches remarkably well with the warming and cooling cycles at various scales. Variability in ocean currents and volcanism also influence the climate.

The fact is that water vapour constitute 90-95% of greenhouse gases on which humans don't have almost any control. CO_2 constitutes less than 4%, of the total greenhouse gases in the atmosphere. Therefore, controlling CO_2 alone may not cool down the atmosphere.

It would be better for the humans to adapt to the natural cycles that come. The scant resources can be utilized on the traditional areas of health, education and shelter and to control the burgeoning problems of pollution.

INSTITUTIONAL DYNAMICS IN DISASTER MANAGEMENT: IMPLICATIONS FOR CLIMATE CHANGE ADAPTATION IN BANGLADESH

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Abstract

Bangladesh, one of the most vulnerable countries to the impacts of climate change, is progressively bringing institutional initiatives for adapting to climate induced disaster. However, major institutional arrangement is only concerned with reactive short-term responses to disaster management, particularly focusing on the relief and rehabilitation programmes. This paper examines current disaster management policies of Bangladesh and role of multi-level stakeholders for adapting to climate changes. The study reveals that centralised decision-making process, weak local government agencies and their little coordination with NGOs, civil society and target vulnerable population impedes successful adaptation practices to a large extent. Despite disaster is a negative phenomenon, the paper argues, it also creates a window of opportunity for policy makers to learn about the barriers of disaster management, as well as, address the key social, physical and economic components of the vulnerable communities and strengthen local government agencies for facilitating adaptation practices.

PERFORMANCE OF DRR STRATEGIES IN CHANGING CLIMATE: A CASE STUDY OF EASTERN U.P.

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Abstract

Historically we have been dealing with the phenomenon of floods through various strategies- structural as well as non-structural. These strategies adopted by the state as well as communities have given both benefits and dis-benefits in the past, this presentation will discuss the results of a cost-benefit analysis exercise of all possible DRR strategies under the changing climate. It was revealed that while hard structural solutions (e.g., embankments) to deal with floods wilt not give very good economic results in the future. At the same time, more decentralized community based soft options will give good economic benefits under various scenarios.

IMPACT OF CLIMATE CHANGE IN THE PAST AND PRESENT : LOOKING THROUGH GEOLOGICAL LENSES

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Climate change is global and essentially natural phenomenon. The earth experiences warming contiguous with cooling in the entire geological time scale. In the last 600 million years there have been four 'Icehouses'. Pleistocene 'Icehouse" recorded thirty glacial cycles, each was punctuated with several intraglacial phases. Changes in the obliquity of earth's axis, its rotational speed, solar variability etc are some of the major causes for climate change.

The earth is getting warmer since end of the Wisconsin glaciations. Ice core and other proxy data document the hottest period in Holocene around 8000 ybp followed by cooling. In the last 2000 years the climate oscillates frequently. Since 1850 AD the temperature is rising.

Climate change has direct impact on sea. The sea level fell 120 m during the last glacial event and again attained the present level 6000 ybp due to melting of polar and continental ice caps. Geological study reveals that sea level rose in pulses allowing the strand lines to form at different depths and time ostensibly explaining rhythmic warming. Minor fluctuations are recorded in last 5000 years owing to regional dryness, eustatic and isostatic adjustments.

In 20th century the rise of earth's temperature was 0.56° C and sea level 10-25 cm. Recent sinking of few islands in Sundarbans area and increase in extreme climate in this subcontinent has evidently little relation with climate change.

Climate change has some positive benefit to human evolution, growth of civilization and economy. Due to recent recession of the glaciers, the huge exposed land mass will be beneficial for mankind like habitation, exploration for minerals and **oil,** tourism etc. Geo-hazardous zones are to be identified and strict adherence of the Rules of Coastal Zone Regulation should be maintained to prevent mass destruction of human and earthy resources during natural disaster.

Assessment climate change of Mazandaran Province (Iran) using Geostatistical methods

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Earth is warming and climate is changing. Reason of this phenomenon is increasing polluted density and green house gases in atmosphere. In this research it was attempted to consider mazandaran climate changes by geo-statistical methods in recent decade. For statistic analysis and nominating long term climate change; precipitation, annual and monthly temperature average, annual mean of min, max temperature of 9 weather stations were used. Then in GIS environment for diverse parameters climate concerning maps were plotted. The results of show the increasing mean temperature during 19%-2005, as regards long term period, and this increasing in central region is evident. While in west region of province there is less changes temperature than the other regions. Study of average min temperature show that No. of days with temperature equal (0-2) °(. particularly in mountain regions was decreased in recent decade. And the increasing change in minimum temperature is obvious. While in plain of province it was -(2 °C in min temperature. Percentage of precipitation, in cost line didnt changed sensible. But in central region toward cost line it is decreasing and central region to south province it is increasing in from.

Keyword: Global warming; Climate change; Geo-Statistical: Geographical Information System; Mazandaran province

Impact of Climate Change on Health in Urban area

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Fifty percent of global population lives in cities and it is expected to increase to 70% by 2050. Asian cities are expected to see more than 60% of this increase and 46% of all urban population growth will occur in cities with less than 5,00,000 population.

Gorakhpur city is an important urban hub of eastern Uttar Pradesh with a population of 6.22 lakhs. The city located in middle of northern India's Gangetic plain belt is expected to receive more rain fall in monsoon months due to climate change impacts as projected on both A2 and B1 scenarios. Topographically, the city has lower gradients causing drainage problem in the majority of low lying areas. With the increase in rainfall in monsoon and the intensity limited to few days the water logged city is expected to observe enhanced area and duration of water logging.

Gorakhpur Environmental Action Group, with the support of Rockefeller Foundation and ISET has recently studied 20% of the 70 wards of the city for analyzing risks and vulnerabilities. It is being observed that the cumulative impact of solid waste, sewerage problems and resulting water logging are causing severe impacts on the health of residents. There is significant increase of vector borne diseases and related health problems as well as contamination of ground water. The lower and lower-middle economic group which constitute more than 60 per cent of population are largely depending on public health services. The risks will have to be addressed in the city's planning and health services and will have to be strengthened for better adaptation of vulnerable communities.

CC Adaptation to water induced hazards: A study in the flood plains of the Brahmaputra river basin in eastern Assam, India

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Floods, flash floods, river-bank erosion and sand casting are the most important water induced hazards in the eastern Brahmaputra basin in Assam located in the northeastern region of India in the eastern Himalayan environs. While floods affect this part of Assam every year, flash floods are a normal feature of the flood regime. Loss of fertile land due to river bank erosion is a chronic hazard in many places, while sand casting, although not a new phenomenon has become more devastating since mid 1990s especially in the northern bank of the Brahmaputra river. These hazards affect all aspects of the land, lives and livelihoods of the communities living in the region very significantly. Both floods and flash floods leave people homeless and displaced, destroy crops, damage public property and development infrastructure, create trauma and shock by rendering many people destitute, cripple their resilience and make people poorer and more vulnerable. Hundreds of villages with fertile agricultural area and important infrastructure have been lost to the rivers due to frequent shifting of the river courses and erosion of river banks. Of late sand casting has emerged as a major disaster causing degradation of thousands of acres of farm land and important ecosystems like wetlands due to deposition of debris, mainly coarse sand particles, by flood waters. The indigenous communities living in these areas have traditionally developed mechanisms ingrained in their life-practices such as house types, agriculture, livestock rearing, food storage, weather and flood prediction etc. to cope with and adapt to the immediate and long-term impacts of such hazards respectively.

Of late significant changes have been observed in the hydro-climatic regime of the Himalayan region resulting in changed nature of water induced hazards in the large river basins like the geo-hydrologically fragile Brahmaputra basin. Climate change is considered as the major driving force causing changes in the nature of flooding and associated hazards in the Himalayan river basins. In the observation of local people in eastern Assam, rainfall has become erratic while floods are now more intense and frequent. Heavy spells of rain occur more often, so do flash floods. On the other hand droughts like situations in the present decade (2001-02, 2005-06 and 2008-09) have also affected agriculture considerably in Assam. As a result all known traditional coping and adaptation practices of the riparian communities living in these areas have been significantly affected making them less effective against the changing nature of hazards. The indigenous adaptation strategies are in a phase of transition while communities are trying to cope with the changed nature of hazards. Moreover, rapid changes occurring in the traditional societies in the last two decades especially in economy, livelihoods, culture and education accruing from state driven development and disaster management programs (or lack of the same) and forces of globalization have also played an important role in people's adaptive decision making. Traditional

coping and adaptation capacity against natural disasters are crucial for the survival and development of the marginalized communities living in highly floods prone areas that are also remote and socioeconomically under-developed especially when existing disaster management and development programmes have not benefited them to the desired extent.

This paper presents the results of a study on the coping and adaptation strategies- both traditional and contemporary that are in practice among the indigenous communities in two remote and socioeconomically under-developed but highly flood prone areas of the Lakhimpur and Dhemaji districts of eastern Assam in the light of the history of the land and the community as well as in the context of the prevailing socio-political and economic scenario. The study, carried out in five villages in the two chosen sites attempts to understand how ethnic communities living in remote and isolated pockets of very high flood risk zones have lived with and adapted to floods and associated water-induced hazards, whether they will be able to cope adequately with the same disasters in future and what could be done to strengthen their relevant adaptation capacity for the present and the future. The study was carried out by Aaranyak (Guwahati, Assam) in collaboration with the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal.

Towards a comprehensive glacial lake outburst flood risk assessment in the Hindu Kush – Himalayas – a methodological approach

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ABSTRACT

Climate change has resulted in the retreat of glaciers in the Hindu Kush – Himalayas (HKH). While deglaciation can cause a suite of impacts, one of the most visible and tangible impacts is the formation of glacial lakes. Some of these lakes can burst out causing large flash flood with potential s to cause significant damages to property, lives and livelihoods. The awareness among scientists, decision makers and media on the glacial lake formation and outburst process has increased in recent years. This has prompted several initiatives related to glacial lakes, and there is need for a concerted and coordinated assessment of the risk for glacial lake outburst floods (GLOF) in the HKH, and their socio-economic implications. At the moment, knowledge of the current GLOF risk in the HKH is incomplete, and a proper risk assessment is often circumvented. There is need for a comprehensive GLOF risk assessment in order to support proper planning of mitigation and adaptation strategies in this context. ICIMOD has developed and advanced a methodological approach for the GLOF risk assessment, which is presented in this paper. Experiences from recent ongoing case studies are also presented.

Keywords: GLOF, glacial lake outburst flood, hazard, vulnerability, risk; downstream impact assessment; dambreak modelling; geophysical investigation

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Resource conserving technologies for mitigation and adaptation to climate change in rice-wheat system

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ABSTRACT

Climate change poses serious threats to productivity and sustainability of the rice-wheat cropping system, the backbone of food security of south Asia. Conservation agriculture involving continuous minimum mechanical soil disturbance, permanent organic soil cover and diversified crop rotations provides opportunities for mitigating greenhouse gas emission and climate change adaptation. Recent research efforts have attempted to develop resource conserving technologies (RCTs), which are more resource efficient, use less inputs, improve production and income, and reduce greenhouse gas (GHG) emission compared to the conventional practices. Resource conserving practices like zero-tillage (ZT) can allow rice–wheat farmers to sow wheat sooner after rice harvest, so the crop heads and fills the grain before the onset of pre-monsoon hot weather. As average temperatures in the region rise, early sowing will become even more important for wheat. The RCTs are increasingly being adopted by farmers in the rice-wheat belt of the Indo-Gangetic Plains because of advantages of labour saving, water saving, and early planting of wheat. The RCTs in rice-wheat system has pronounced effects on mitigation of GHG emission and adaptation to climate change. It has been showed that global warming potential (GWP) reduced in direct drill-seeded rice and wheat on beds or with ZT compared to conventional puddled transplanted rice and tilled wheat. Yields of rice and wheat in heat and water-stressed environments can also be raised significantly by adopting RCTs, which minimize unfavorable environmental impacts, especially in small and medium-scale farms.

Climate change impacts on agricultural productions –adaptation and mitigation strategies

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Abstract

Increased evidence over the past few decades indicate significant changes in climate are taking place worldwide due to enhanced human activities. The impact of climate change on agriculture will be one of the major factors influencing the future food security of mankind. Understanding of the weather changes over the period of time and adjusting the management practices towards the achieving better harvest is a challenge to the growth of agricultural sector as a whole. India being a large country with 1.15 billion population the likely impact of climate change on agricultural productivity is a great concern to the scientist and planners. There lies a challenge to reach the target of 300 million tons of food grains by 2020 in view of the projected climate change. In order to meet the challenges posed by the climate change, the Indian Council of Agricultural Research has initiated a network programme on climate change during X plan period and is operating at 23 centres presently at different ICAR and State Agricultural Universities with the objectives viz.,

- To identify the regions experiencing significant climate change and variability.
- To develop methodologies for assessing the impacts of climate change on agricultural productivity in various agro-ecological regions
- To suggest suitable interventions for reducing the impacts of climate change on agricultural productivity

The results with respective to impact assessment, adaptation and mitigation strategies obtained over the period 2004-2008 from agricultural, horticultural and plantation crops, climate, soils, water resources, livestock & fisheries are presented in detail.

Mainstreaming Adaptation to Climate Change and Disaster Resilience into City Planning and Management Processes

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Abstract

Cities around the world, from New Orleans, USA to Ho Chi Minh, Vietnam are facing an increase in the frequency and severity of climatic and other natural disasters. These factors will, in turn, put people and assets at greater risk of impacts of these events. For example, a recent OECD study (Nicholls et al., 2007) reveals that 90% of the total estimated asset exposure in large port cities (with populations exceeding one million) is concentrated in only eight nations (China, US, India, Japan, Netherlands, Thailand, Vietnam and Bangladesh). In addition to the threat of climate change, the impacts of natural disasters, in the form of typhoons, floods, earthquakes, landslides and tsunamis, are rising worldwide. In 2007, more than 201 million people were affected by 405 natural disasters, marking a forty percent increase in the number of people affected over the previous year. In 2008, although a decrease in the number of disaster events (321) was noted, the devastation caused by these events increased, impacting over 211 million people and killing 235,000, and with property damage estimated at US$181 billion (UN-ISDR, 2009).This paper presents an incorporated analytic framework for tackling climate change through mainstreaming disaster risk management into overall development planning in urban areas. It discusses the ongoing application of the "Climate Resilient Cities" framework in East Asia, the Middle East, and Africa. This initial empirical experience points to the importance of having the following aspects in place for sustainable programs of resilience: information and sensitization; leadership and institutional coordination; stakeholder consultation and ownership; and incentive structures for political agents to absorb costs now for benefits that will be realized later.

CLIMATE CHANGE AND DISASTERS: AN INDIAN PERSPECTIVE

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Abstract

Climate change is evident from the observations of increase in global average air and ocean temperatures, precipitation and extreme rainfall, widespread melting of snow and ice, storms/storm surges/coastal flooding and rising global mean sea level, as recorded in the Fourth Assessment Report of IPCC. In future, Climate change is expected to increase the frequency and intensity of current extreme weather/ hydro-meteorological events, greater monsoon variability and also the emergence of new disaster i.e. sea level rise and new vulnerabilities with differential spatial and socio-economic impacts on communities. This unprecedented increase is expected to have severe impact on the hydrological cycle, water resource (drought, flood, drinking water, forest & ecosystems, sea level / coastal area /losses of coastal wetlands and mangroves), food security, health and other related areas.

The impact would be particularly disasters for developing countries, including India and further degrade the resilience of poor, vulnerable communities, which make up between one quarter and one half of the population of most Indian cities. Low level technology development in the villages together with social, economic and gender inequities enhance the vulnerability and sufferings of the largely illiterate, unskilled, and resource-poor fishing, farming and landless labour communities. Their resilience to bounce back to pre-disaster level of normality is highly limited. These, in turn, impede sustainable development widely undertaken in accordance with the Millennium Development Goals (MDG). Under these circumstances, the largely modern science and technology-based sophisticated early warning systems are unlikely to be of help to their fullest potential. The Super Cyclone in 1999, Drought in 2002 /2009, Tsunami in 2004, Heat & cold wave and Flood / flash flood in recent years in rural & urban areas are a *'wake-up call'* from technological, social and economic points of view. This brings out the urgent need to address sustainable alternate livelihoods to enhance resilience. In these circumstances, vulnerability assessment is a powerful tool in the examination of societal well-being in the face of climatic change for better management which must integrate knowledge about the environment (climate, ecosystems, water, associated pollution and change) with knowledge about humans and their activities (agriculture/forestry/fishing, resource management, political governance, energy use, culture) to determine a holistic picture of how sensitive particular places are and how resilient to the kinds of changes that might be associated with climate change.

LANDSLIDES AND CLIMATE CHANGE: CASE STUDY FROM SATLUJ VALLEY, NORTHWESTERN HIMALAYA, INDIA

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Abstract

The paper deals with the study of active and palaeo-landslides in the Satluj valley. The relationship between the temporal occurrence of landslides and the climate change was studied and it has been recorded that there is an increase in landslide activity with the climate change. The increase in landslide activity has mainly been reported at the boundary between sub-humid temperate zone and the semi-arid to arid temperate zone which is mainly influenced by the northeastward transgression of rains. This has resulted into more area falling under the influence of rains, thus the slopes which were stable under dry condition are susceptible to landslide in the present day climatic scenario.

Sea-level changes along the Indian coasts: current trends, future projections and impacts at the coast

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Abstract

Sea level changes at the coast occur mainly in two forms. Mean sea-level rise as well as changes in extreme sea level (storm surges). The former is a direct consequence of global warming caused by melting of glaciers and thermal expansion in the ocean, while the latter is caused primarily due to mean sea-level rise and changes in the frequency and intensity of cyclones.

In the Third Assessment Report of the Inter Governmental Panel on Climate Change (IPCC), Church et al. (2001) reported a global mean-sea-level rise of 1 to 2 mm/year, as estimated from the past tide-gauge records. Later, in the Fourth Assessment Report, Bindoff et al. (2007) reported that based on the best tide-gauge records, the global mean-sea-level rise had been at a rate of 1.8 ± 0.5 mm/year during the period of 1963 to 2003. An analysis of long tide-gauge records along the coast of north Indian Ocean shows an average sea-level-rise trend of 1.30 mm/year.

Future projections of mean-sea-level rise are available in the Fourth Assessment Report of the IPCC. These projections, which vary for different climate scenarios, are on a global scale. For instance, for the A1B scenario, the trends of projected mean-sea-level rise are about 3.8 mm/year for the 21st century (Bindoff et al., 2007, Meehl et al., 2007).

Future changes in tropical cyclones in the Bay of Bengal and storm surges along the east coast are examined using the simulation results from a regional climate model (HadRM2) and a storm surge model, driven by winds from HadRM2. In the Bay of Bengal, increased occurrence of intense cyclones as well as higher surges along the coast are found in a model run of increased concentrations of green house gases (IS92a scenario), when compared to a control run of constant level of green house gas concentrations.

Environment, Climate-change and Disasters – Strategic Assessment and Risk Communication Protocol for India

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"Integrating Environment, Climate-change and Disasters" is very much alike concluding 'environmental management' as single common solution to two (climate-change, disasters) and more questions of, for example – development, livelihood, sustainability, conflicts-resolution, terrorism, naxalism, and over and above – human well being. 'Climate-change' awareness attributable to IPCC, UNFCCC, UNEP, IUCN, MoEF, ecologists, and future-thinkers at various levels, has brought in the realisation the need to understand the inter-relatedness of natural/human environmental systems, accelerating and aggravating threats, increasing susceptibility of resources and life, and the sustainability of development. Climate-change is a globe-wide phenomenon influencing differently different regions and systems/components, thus calling for region-specific and eco-component-wise interventions for adaptation strategies. However, 'who' is to adapt, for 'what' to adapt and where to 'adapt' are the continual pursuits.

Societies like India, used 'God' most often to bypass the accountability and therefore the term 'natural disaster – act of God' prevailed pretty long. Negatively, the 'climate-change' concern has given a new excuse for the defaulters to skip from responsibility of been cause in the aggravating the challenge – increasing disasters, vulnerability, and reduced GHG sink along – greencover, waterbodies, etc. besides creating the conditions of more and lasting destructions in the event of even a common intensity disaster. Accusing 'climate-change' is a fashion 'buzzword' in fund markets and business diplomacy. There is a need to carryout a systematic 'strategic impact assessment' or cyclic relationship of climate-change and disasters in the broach framework of environmental systems (local, regional and wider contexts). Socio-political scientists now join 'ecologists' in defining the stories of past/recent instability and conflicts in Indian regions of Punjab, J&K, Assam, Chattisgarh, Orissa, Jharkhand, Bihar, Karnataka, etc. as the public face of man-made environmental/natural resource challenges. Climate-change has to be now looked into regional/local ecological contexts, to address the global challenge.

Communication technology using space/satellite-support/data, GIS, bio-informatics / chemoinformatics, web-enabled systems along public media like – television, radio, mobile network has been looked in for disaster management, but has to be re-oriented for intensive application in supporting 'prevention' and 'mitigation' so as to workout the specific risk-communication protocols, an specific need under the 'CC adaptation' agenda. The present paper offers an innovative protocols based on case experiences of region-specific consultations on 'climate-change and disasters' and 'environment and disaster' programmes in coastal, desert-prone, north-India, Bundelkhand, lessons of UNDP-MoEF project "Climate-resilient development and adaptation' and 'environmental management planning for hilly districts". The discussion provides a framework charter for sustainability through integrated approach and also an institutional support plan at national, state/regional, district and local levels.