IMPACT OF CLIMATE CHANGE, VARIABILITY, AND EXTREME RAINFALL EVENTS ON AGRICULTURAL PRODUCTION AND FOOD INSECURITY IN ORISSA

***Aastha Gulati[a], Palak Gupta[b], Meenakshi Jha[b], P. Parth Sarthi[c] and Kumar Vishal[d]**

[a]Department of Natural Resources Management, TERI University, Vasant Kunj, New Delhi, India
[b]Department of Food and Nutrition, Lady Irwin College, New Delhi, India (palak_aquarian@yahoo.com)
[c]Associate Fellow/ Adjunct Faculty, TERI/ TERI University, India Habitat Center, Lodhi Road, New Delhi
[d]Senior Consultant, Emergent Ventures India, Gurgaon, Haryana

KEYWORDS: Climate Change, Extreme Rainfall Events, Food Insecurity, Adaptation Strategy.

ABSTRACT:

The world's surface temperature has increased at an unprecedented rate due to global warming. This has impacted the hydrological cycle and rainfall pattern. The Indian Summer Monsoon Rainfall season (ISMR), which plays a very important role in regulating the floods and droughts, regulates the crop yield, well being of the society, employment generation, and food insecurity. Food insecurity is the limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways. Availability, access, and assimilation are broadly the three main dimensions of food security. All this is related to the economy of the state and consequently of the country. Thus, the paper studies and identifies drought variability pattern; consequential impact on food availability and thereby suggesting 'No-regret' adaptive strategies to improve food insecurity across the state of Orissa. The rainfall data for the scientific analysis was obtained from Climatic Research Unit, U.K., for time period of 1901-2002. Univariate analysis and bivariate analysis were carried out. Univariate analysis revealed that the months of June- September (ISMR) contributes 79% of the annual rainfall in the state, with maximum rainfall in the month of August. Cuttack was the least vulnerable district as it experienced the least number of droughts, while Rayagada was the most vulnerable district. To improve the economic conditions and food insecurity in Orissa few adaptive strategies were suggested - Need for linkage with employment generation schemes, skill up-gradation programmes, and promotion of available untapped resource-based livelihoods were highlighted.

1. INTRODUCTION

Human and animal deaths, migration, economic losses and social effects were very common in Africa, Asia, America, Europe, and Oceania during the twentieth century. Frequent droughts and floods in Asia, still results in miseries, erode livelihoods, damage integrity of natural ecosystems, and cause diseases or deaths due to poor quality water and hunger (Samara, 2004).

Climate change is evident from the observations of increase in global average air temperature, sea surface temperature, extreme weather events, widespread melting of snow and ice, storm surges, and coastal flooding (IPCC 2007). Climate change is a global problem, and India is subjected to it, due to its unique geophysical and hydro-climatic conditions (Mall & Kumar, 2009). According to O'Brien et al. (2004), climate change is expected to change the existing vulnerability profile of India. The country has been vulnerable to vagaries such as droughts, floods, heat waves and cyclones since time immemorial (BMTPC 1997; High Powered Committee 2002). These vagaries have left behind death and destruction with huge impact on the developing economy of the country. There is growing evidence that the changing climate has implications for India with studies projecting future possible reductions in monsoon related rainfall in some parts of the country and an increase in other parts. This unprecedented change in the monsoon related rainfall is expected to have severe impact on the hydrological cycle (Mall & Kumar, 2009), thus, changing the pattern, frequency, and intensity of extreme rainfall events (floods and droughts). According to IPCC (2007), globally, the area affected by drought has increased since the 1970s. It is likely that the frequency and the intensity of such extreme events will increase (IPCC, 2007) and that will result in a negative effect on the Indian economy (Mall et al., 2006). Presently in India, about 68% area is liable to droughts (Mall & Kumar, 2009). Nearly a rural population of 700 million people in the country is directly dependent on climate-sensitive sectors (agriculture, forests, and fisheries), and natural resources (water, biodiversity, coastal regions, mangroves, and grasslands) for their subsistence and livelihood (NATCOM, 2008). Guhathakurta & Rajeevan (2007), state that the Indian economy is still largely dependent on agricultural sector, with nearly 70% of the working population dependent on agricultural activities for their livelihood (Krishna Kumar, 2004). NATCOM report (2008), reports that over 60% of the crop area under the rain-fed agriculture in the country is highly vulnerable to climate variability and change. Human lives and health are expected to be affected by extreme rainfall events, both directly through increased mortality due to events such as floods and droughts (Patz et al., 1998), and also indirectly through effects of morbidity and mortality related to changes in food security and financial security.

* aastha.pink@gmail.com

Food insecurity means limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways (Carlson et al, 1999). Broadly, food security has three dimensions – availability, access and assimilation. Shaw (2006) mentions that, although communities are equipped with traditional knowledge and wisdom, new practices and policies are required to enable them to cope with the changing climate, thereby providing them with means to sustain their livelihood. The Emergency Database (EM-DAT) of Centre for Research on the Epidemiology of Disasters (CRED) reports the impact of drought events in India. According to this database drought events have affected nearly 1,061 million people and killed 4.25 million people in India during 1900– 2006 (Center for Research on Epidemiology of Disasters, 2006). Increase in intensity and frequency of drought events in future are likely to further threaten the food security and sustainability of the country. The National Commission on Flood (1980), identified Uttar Pradesh, Bihar, Assam, West Bengal, and Orissa as the major flood prone regions in India. INTACH (1986), reports that in areas like Rajasthan, Gujarat, Andhra Pradesh, Maharashtra, and Orissa, rainfall is highly deviant and drought situation is prevalent. Therefore, the study area is the state, which is one of its own kinds across the country, i.e., Orissa, where the incidence of both, floods and droughts, is high. The highly uneven and erratic rainfall pattern across the state makes the eastern districts flood prone, while those in the west are drought prone. Thus, voiding the misconception that drought events occur only in arid and semi-arid regions. Since, droughts are departure from long-term annual average, they may also occur in high rainfall regions.

Agriculture in the state is mainly rain-fed, as only 35% of the cultivated area of 64 lakh hectares has irrigation facilities from various sources, some of which are again dependent on rainfall (OSDMA, 2002-03). The state's population of 37 million resides mainly in rural areas (85%), with a large population of marginal farmers (Census, 2001); indicating high level of dependence on agriculture. World Bank report (2008), estimated that about 75% of cultivated area in the state is rainfall dependent. Thus, the monsoonal behaviour across the state holds the key to agricultural productivity, and consequent food security. Nearly, 86% of the annual rainfall in the state is contributed by the southwest monsoon (CGWB, 1999). A delayed/untimely monsoon, and/or less precipitation during the season are indicative of poor crop yield and drought situation, resulting in damaging consequences and reduced coping capacities. Orissa has less experience of coping with droughts, in comparison to floods, resulting in poor preparedness. Hence, the impact of drought events may be more severe in the state. The present study, therefore, emphasizes only on the (meteorological) drought events across all the districts of the state. Meteorological drought indicates the deficiency of rainfall compared to normal rainfall in a given region over an extended period of time. According to Sinha Ray (2000), it is classified as moderate drought if the rainfall deficit is 26-50% and severe drought when the deficit exceeds 50% of normal. The objectives defining this study are: (i) to identify and highlight the variability and pattern of drought events on a regional scale, and (ii) to suggest 'No-regret' adaptation strategies to cope with the consequences of drought events and prevent food insecurity.

2. METHODOLOGY

2.1 Study Setting

This study was focussed on the state of Orissa, which is preeminently agricultural. Orissa has total number of 30 districts which are spread over the area of 1, 55,707 km^2, and are bounded between North latitudes 17^{0}49' to 22^{0}34' and East longitude 81^{0}24' to 87^{0}29'. In the present study all the 30 districts were included (Figure 1).

Figure 1. Study area – Orissa (Source: www.opepa.in)

2.2 Data Collection

2.2.1 Climate data: High-resolution rainfall data for all the districts of the state of Orissa was obtained from Climatic Research Unit (CRU), U.K. The data was collected for each month for a period of approximately hundred years (1901-2002). Monthly data for all the districts from Indian Meteorological Department (IMD) for a time period of fifty years (1901-1950) was also obtained.

2.2.2 Field visit: To understand the perception of the local community and their cultural practices in order to suggest programmatically feasible 'No regret' adaptation strategies field visit was conducted to selected districts by the investigator.

2.3 Data analysis

The data from CRU was used to identify the change in the rainfall pattern on regional and temporal scale and its associated changes in the frequency of drought events across the districts of the state.

'Percent of normal' drought index was used to define drought in various districts quantitatively. 'Percent of normal' drought index was calculated by dividing actual precipitation by normal precipitation considered to be a thirty scale range, from a single month to a group of months representing a particular season to an annual year. Normal precipitation to a specific region is considered to be 100%.

The percent departure of rainfall from the average of rainfall in JJAS (June, July, August, and September) for the period of 1901-2002 for all districts of Orissa was calculated using the high-resolution data from CRU. Univariate analysis using Excel 2003 was done, in which the mean, standard deviation, and coefficient of variation was calculated for the state as a whole. Seasonal trend and monthly (June, July, August, and September) contribution of rainfall to the annual rainfall of the state was also studied. Followed by this, drought frequency map was generated using ArcView GIS 3.2 software. Coefficient of correlation using the Karl Pearson's Correlation Analysis statistical tool was calculated using SPSS version-16. for the rainfall data set taken from CRU, and the rainfall data set obtained from IMD. This was done to assess the level of correlation between monthly precipitations of the two data sets, for all thirty districts of Orissa, for the period of 1901-1950.

3. RESULTS

Monthly, seasonal, and annual rainfall series for the entire state was constructed based on the monthly data of the districts taken from CRU. Univariate analysis (mean, standard deviation and coefficient of variation) calculated for the same, revealed that the mean Indian Summer Monsoonal Rainfall (June, July, August, and September) (1025.84 millimetres) contributes 78.7% of the annual rainfall. Contribution of pre-monsoon (March, April, and May) and post-monsoon (October, November, and December) rainfall to the annual rainfall is 7.7% and 11.1% respectively (Figure 2). Coefficient of variation is higher during the months of November, December, January, February, and March. The mean (calculated with the data of 1901-2002) rainfall of August, i.e., 319.7 millimetre is the highest and contributes 24.55% of annual rainfall. The July rainfall is slightly lower (297.59 millimetre), which contributes 22.85% of the annual rainfall. The June and September rainfall are almost similar and they contribute 14.9% and 16.6% of the annual rainfall respectively (Figure 3).

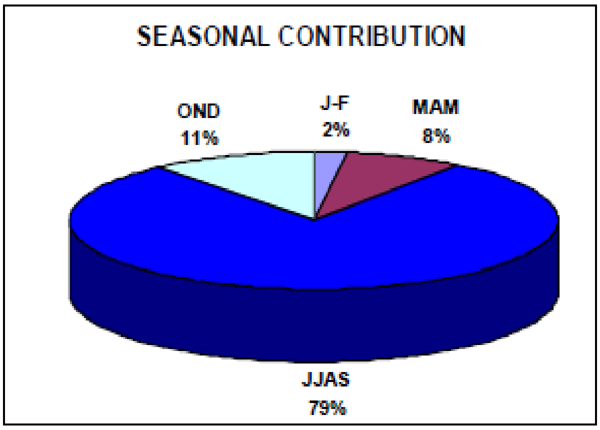

Figure 2. Seasonal Contribution to Annual Rainfall Across Orissa

The results obtained from the calculation of percent departure of rainfall from the average of rainfall in JJAS for the period of 1901-2002, for all districts of Orissa, using the rainfall data set obtained from CRU, discerned that out of approximately hundred years (1901-2002), the years 1901, 1907, 1935, 1950, 1954, 1966, 1973, 1979 showed negative departures (with +/-19 as the normal) for majority of the districts (>50%). The correlation coefficient for the monthly rainfall series (1901- 1950) from CRU and IMD on a district level was observed to be very large (r>0.90, p<0.01 for all districts). Drought frequency map was made for the entire state of Orissa. On studying this map (Figure 4), it was observed that Cuttack was the least vulnerable district as it experienced the least number of droughts, while Rayagada was the most vulnerable district as it experienced maximum number of drought events.

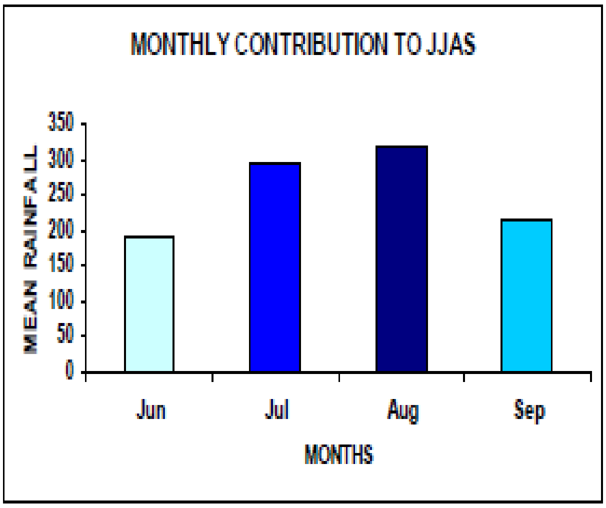

Figure 3. Monthly Rainfall Contribution to JJAS Across ORISSA

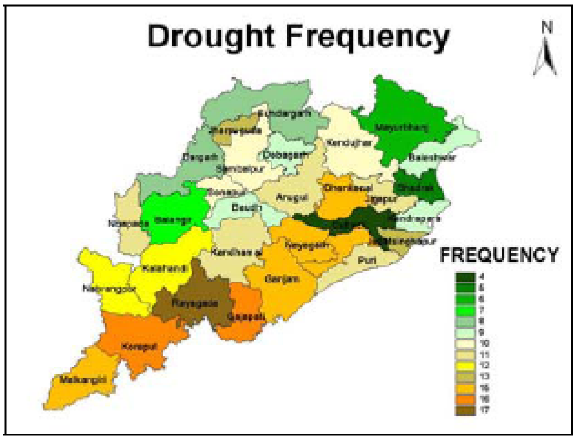

Figure 4. Frequency of Drought Events Across the Districts of Orissa

In years 1901, 1907, 1950 and 1979 drought was severe & affected most of the districts (more than 20 districts) of Orissa, including some of the cyclone and flood affected districts (Jagatsinghpur, Khordha, Kendrapara, Puri, Jajpur, and Ganjam).

4. DISCUSSION

Though climate change is seen as a relatively recent phenomenon, individuals, societies and many parts of the world are used to adapting to a range of environmental and socio-economic stresses like drought. Observations state that Orissa has been subjected to climate variability and extreme weather events each year in many ways. Also, that identified meteorological drought years coincided with agricultural drought years across the state. Many studies have showed that climate change affects food security in several and complex ways. Gregory et al, 2005 mentioned that reliance on purchased food increases in drought years due to losses in food production leading to an increase in poverty due to the synergistic action of other drivers such as rising food prices and unemployment. Therefore to prevent food insecurity in the state of Orissa various adaptive strategies have been stressed upon. These are:

Water harvesting and conservation: is considered very useful for groundwater recharge both when rainfall is deficient and when there are floods. Every household's minimum water requirements can be easily met by collecting rainwater locally from community ponds, or by diverting and storing water from local streams and springs. Harvesting and conservation of flood water should be encouraged to rejuvenate depleted aquifers by adopting groundwater recharge techniques, such as percolation tanks. This would improve water availability and create a water buffer for dealing with successive droughts/floods. Use of water saving technologies such as drip and sprinkler irrigation systems can also be encouraged for achieving higher irrigation efficiencies.

Afforestation: or development of forests in areas susceptible to periodic recurrence of drought is an effective drought-resistant measure. Areas which are devoid of tree growth need to be covered with drought-resistant vegetation, for example, Jackfruit plantation. For effective development of forests, afforestation should be financially supported through the social forestry program or watershed development program which normally includes a budget for this activity.

Community participation: is an essential feature of drought/flood mitigation programmes. As local water management and rainwater harvesting hold the key to drought mitigation, Government policies should emphasize community-based water resource management. Institutions such as 'Pani Panchayat' program can play important roles in managing water resources at the micro level. Further, there is a need to strengthen Gram Sabhas and Panchayati Raj Institutions which help in meeting the basic entitlements through provision of work and food to people affected by drought. Communities can be involved at the local level preparedness planning, vulnerability mapping while preparing the community level drought management plans (Hayes et al. 2004).

Women's self-help groups: can play an important role in a large number of measures targeted at drought/flood mitigation. They could be involved in small scale industries, running PDS shops, Aanganwadis and day care centres, and overseeing water distribution and utilization in their community.

Employment opportunities outside the agricultural sector: such as engaging in construction activities, poultry farming can reduce the impacts of extreme rainfall events on farmers.

Awareness creation: through adult and non-formal education. There is a need to **generate community awareness about existing livelihood generation government programs** and link the community with respective government departments implementing these schemes.

Skill up-gradation, training, community linkages with potential private employers/industrial units can improve employability and opportunity to obtain gainful livelihood. Any perturbation in agriculture can considerably affect the food systems and thus increase the vulnerability of large fraction of the resource poor population (Aggarwal, 2008). Therefore, maintaining buffer stocks of food helps in managing periods of scarcity.

Improved land-use and natural resource management policies and institutions: (Aggarwal, 2008)**.** Crop insurance, subsidies, and pricing policies related to water and energy could help in coping with the disasters. Rational pricing of surface and groundwater, for example, can arrest its excessive and injudicious use. Policies and incentives should be evolved that would encourage farmers to sequester carbon in the soil and thus, improve soil health, water use, and energy more efficiently.

CONCLUSION

The unique geo-climatic conditions of Orissa make this Indian state vulnerable to various natural hazards. Coastal districts are prone to floods and cyclones, while drought is particularly frequent and severe in the western districts of the state. Due to being far from conclusive and lack of dependable regional scenarios, it suffices to discern that the governments at all the levels need to be on watch for dealing with any surprises. Under these circumstances, identification of appropriate adaptation options seemed to be the right policy. The right adaptation policy was to look at the existing vulnerability reduction mechanisms and improve upon them by plugging the gaps. Therefore, in this study the available evidences of drought events across the state of Orissa were also considered and the existing preparedness and mitigation mechanisms for drought risk reduction in the state were assessed. Identification of noregret options that would improve the existing interventions, hence reducing the vulnerabilities to a greater extent, was done. Among all the adaptation measures identified and elaborated, the community based preparedness and mitigation planning is the key as it would greatly enhance the capacities of communities by broadening their coping range. Similarly, there is a greater need for clarity in center-state relationships in dealing with the extreme rainfall events such as droughts and floods.

ACKNOWLEDGEMENTS

We are thankful to the authorities of NIDM and TERI University for their help and support. We are extremely grateful to Mrs. Ameeta Jena, Mr. Purnendu Sandhibigraha, for helping us in data collection in Orissa, and making our field visit to the state a wonderful and an extremely learning experience. We would like to acknowledge Mr. Barik, Orissa State Disaster Mitigation Authority, Mr. Ranjan Rauth Roy, librarian, Gopabandhu Academy of Administration, and Orissa State Library for giving us their precious time, and helping us in data collection. I would also like to extend my sincere thanks to Mr. Sanjay Patnaik, Director, Peoples' forum and Mrs. Manju Dhal, Director, C.A.R.D. for helping us interact with the community, and for providing us information on the relief activities taken up the NGOs during floods and droughts.

REFERENCES

Aggarwal, P.K., 2008. Global climate change and Indian agriculture: impacts, adaptation, and mitigation. International Journal of Agricultural Sciences, 78(10), pp. 911-919.

BMTPC, 1997. Vulnerability atlas of India, Parts I–III, building materials and technology promotion council. New Delhi: India

Carlson, S.J., Andrews, M.S., & Bickel, G.W., 1999. Measuring food insecurity and hunger in the United States: development of a national benchmark measure and prevalence estimates. Journal of Nutrition, 129, pp. S510–S516.

Census of India, 2001. http://www.censusindia.gov.in/population_finder/State_Master. aspx?State_Code=21 (accessed 29 April 2009)

Center for Research on Epidemiology of Disasters, 2006, India country profile of natural disasters, EM-DAT: The International Disaster Database, http://www.emdat.net/disasters/Visualisation/profiles/countryprofile.php. (accessed 20 March 2009)

Central Ground Water Board, 1999. Ground water year book: 1998-99. South Eastern Region, Bhubaneshwar.

Gregory, P.J., Ingram J.S.I., & Brklacich, M., 2005. Climate change and food security. Philos Trans R Soc Lond B Biol Sci. 360(1463), pp. 2139–2148

Guhathakurta, P., & Rajeevan, M., 2007. Trends in the rainfall pattern over India. International Journal of Climatology, 28, pp. 1453-1469.

Hayes, M.J., Wilhelmi, O.V., & Knutson, C.L., 2004. Reducing drought risk: Bridging theory and practice. Natural Hazard, (2), p.106–113.

High Powered Committee, 2002. Disaster management report. Department of Agriculture and Cooperation, Ministry of Agriculture: Government of India. p. 107.

INTACH, 1986. Drought development and desertification. Proceedings of Seminar on Control of Drought, Desertification and Famine. India.

IPCC (Intergovernmental Panel on Climate Change), 2007. Climate Change 2007: Impacts, Adaptation, and Vulnerability. Summary for Policymakers. Contribution of Working Group II to the Fourth Assessment Report of the IPCC.

Krishna Kumar K., et al., 2004. Climate impacts on Indian Agriculture. Int. J. Climatol., 24, pp. 1375-1393.

Mall R. K., Gupta, A., Singh, R., & Rathore, L.S., 2006. Water Resources and Climate Change-An Indian Perspective. Current Science, 90 (12), pp. 1610-1626.

Mall, R.K. & Kumar, S., 2009. Climate change and disaster management: Special reference to water resources. [Unpublished]

NATCOM, n.d., Vulnerability Assessment and adaptation, India: Ministry of Environment and Forest, http://www.natcomindia.org/pdfs/chapter3.pdf (accessed 16 March 2009)

O'Brien K. et al., 2004. Mapping vulnerability to multiple stressors: Climate change and globalization in India. Global Environmental Change, 14, pp. 303–313.

OSDMA, 2002-03. Annual Report on Natural Calamities 2002-03. Special Relief Commissioner, Revenue Department, Orissa State Disaster Mitigation Authority, Government of Orissa.

Patz, J.A., et al., 1998. Predicting key malaria transmission factors, biting and entomological inoculation rates, using modeled soil moisture in Kenya. Tropical Medicine and International Health, 3, pp. 818-827.

Shaw, R., Community-based climate change adaptation in Vietnam: inter-linkages of environment, disaster, and human security. In: Sonak, S., 2006. Multiple dimensions of global environmental change, New Delhi, India: TERI Press. p. 521-547.

Sinha Ray, K.C., 2000. Role of Drought Early Warning Systems for Sustainable Agricultural Research in India. Proceedings of an expert group meeting, September5-7, 2000. Lisbon: Portugal.

World Bank, 2008. Climate Change Impacts in Drought and Flood Affected Areas: Case Studies in India. Report No. 43946-IN. South Asia Region: India Country Management Unit.