WATER AND CLIMATE INDUCED VULNERABILITY IN NORTHEAST INDIA: CONCERNS FOR ENVIRONMENTAL SECURITY AND SUSTAINABILITY

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Introduction

Vulnerability and Environmental Security are fast emerging as frontline research areas in the realm of global change and earth system science in a world driven mainly by globalisation and climate change. It is worthwhile to consider some basic concepts of vulnerability literature before embarking on to explore the sources and extent of water and climate-induced vulnerability in northeast India. A 'hazard' can be defined as a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. A 'disaster' is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope with the consequences using its own resources. A disaster is the product of a hazard such as earthquake, flood or wind storm coinciding with a vulnerable situation in, for example, communities, cities or villages. There are two main components in this definition: hazard and vulnerability. Without vulnerability or hazard there is no disaster. A disaster occurs when hazards and vulnerability meet.

Vulnerability is essentially a detrimental social response to environmental events and changes. It can be defined as the likelihood of injury, death, loss, disruption of livelihood or other harm in an extreme event, and/or unusual difficulties in recovering from such effects (Wisner, 2002). In the context of disasters, vulnerability may refer to a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of a community to the impact of hazards (ISDR, 2002). A hazard is the occurrence of an extreme event with a (low) frequency (Bogardi, 2004) while disaster is a hazard of large proportions and impact. A risk is the association of the probability of occurrence of the extreme event (hazard/disaster) with the (economic and financial) losses it would imply (Plate, 2002; Kron, 2003). Taken from the vulnerability standpoint and incorporating the resources, within the community, risk can be defined as RISK = HAZARD x VULNERABILITY/CAPACITY, where capacity is a combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. The concepts of vulnerability and risk are finding ample use in emerging fields of research like environmental and human security vis-à-vis escalating impacts of climate change in all spheres of global environment and human society.

Trends in Global Climate Change

The most recent assessment of the earth's climatic environment by the fourth assessment report of the IPCC has caused alarm all over the world regarding the planet's future climate. According to the report there is an unequivocal warming trend in the earth's climate system and most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic (human) greenhouse gas concentrations and therefore human systems' contribution to this accelerated rise in earth's surface temperatures is much more responsible than natural climatic processes alone. Global atmospheric concentrations of principal green house gases (carbon dioxide, methane, and nitrous oxide) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values over the past 650,000 years. Global GHG emissions have grown since pre-industrial times with an increase of 70% between 1970 and 2004. CO_2 has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. Eleven of the last twelve years (1995-2006) were among the 12 warmest years in the instrumental period since 1850. Between 1906-2005 earth's surface temperatures have increased by 0.74°C in 100 years wherein warming was faster in the last 50 years at the rate of 0.13°C per decade almost twice the per decade rate for the last 100 years. Global average sea level has risen at an average rate of 1.8 mm per year over 1961 to 2003, the rate being faster, about 3.1 between 1993 and 2003. Long-term trends from 1900 to 2005 have been observed in precipitation amount over many large regions. Rainfall has significantly increased in eastern parts of North and South America, northern Europe and northern and central Asia. On the contrary rainfall has decreased in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. (IPCC, 2007a; IPCC 2007b)

Climate change has cascading and far reaching affects on almost every aspect of environment and societies as already observed amply all over the world. The prognostications for the 21st century climate are serious enough to warrant the maximum possible efforts on a war footing to deal with the challenge of mitigating the adverse impacts. The developing countries of the world with large populations living in poverty and degraded environments and reliant on primary production are most vulnerable to the impacts of global climate change. The northeast Indian region of India is expected to be highly prone to the consequences to climate change because of its geo-ecological fragility, strategic location vis-à-vis the eastern Himalayan landscape and international borders, its trans-boundary river basins and its inherent socio-economic instabilities. Environmental security and sustainability of the region are and will be greatly challenged by these impacts.

Climate Change and Northeast India

Since the General Circulation Models (GCM) do not provide high resolution information for small regions, the impacts of climate change on regions like northeast India are less explored and less known till now making the future scenarios more uncertain for vulnerability assessment and risk management. However, certain indicators point to impacts being already visible in the region.

Studies on rainfall and the temperature regimes of northeast India indicate that there is no significant trend in rainfall for the region as a whole i.e. rainfall is neither increasing nor decreasing appreciably for the region as a whole (Das and Goswami, 2003; Das, 2004). However, for a part of the region that the meteorologists of the country officially refer to as the 'South Assam Meteorological Subdivision'(that covers mainly the hill states of Nagaland, Manipur, Mizoram and Tripura and parts of the Barail Hills in southern Assam), a significant change in seasonal rainfall has been observed. The summer monsoon rainfall is found to be decreasing over this region significantly during the last century at an approximate rate of 11 mm per decade (Das 2004, Mirza et al., 1998).

Analysis of long-term temperature data for the region points to a distinctly rising trend in surface air temperatures. The annual mean maximum temperatures in the region are rising at the rate of +0.11°C per decade. The annual mean temperatures are also increasing at a rate of 0.04°C per decade in the region (Das 2004, Pant and Rupa Kumar, 1997). This may well be a manifestation of the regional impact of global warming/climate change. However, more rigorous study needs to be done at regional scale before anything can be said conclusively.

Several districts of Assam were badly affected due to drought like situations consecutively for two years in 2005 and 2006 which had a signature of climate change on them as vindicated by the IPCC report of 2007(IPCC, 2007a). In the intense drought-like conditions that prevailed in as many as 15 districts of Assam during the summer monsoon months of the year 2006 owing mainly to below normal (nearly 40%) rainfall in the region, more than 75% of the 26 million people associated with livelihoods related to agriculture in these districts were affected and the state suffered a loss of more than 100 crores due to crop failure and other peripheral affects. Other states of the region also received rainfall 30 – 40 % below their normal rainfall except Mizoram. Normally such fluctuations are considered as results of inter-annual variability of the monsoons, but then climate change impacts are supposed to affect the southwest monsoon also by increasing the normal mode of its variability.

Besides such scientific evidences, which are however few, individual and collective opinions in various parts of the region bear references to what may be construed as increased variability or changes in local climates. Such anecdotal references talk of irregular rainfall pattern with rainfall starting quite early in the region (say in January), heavy rainfall events (extreme rainfall) and flash floods becoming more frequent and dry periods becoming longer in various parts of the region. According to popular perceptions strong winds that usually occur in the month of February have advanced to January in some places; it feels colder in February than in November and timing and quantity of precipitation is undergoing change. The year 2005 saw prolonged dry periods in Mizoram with many springs and streams drying up accompanied by large scale landslides (ICIMOD, 2008). Rainfall occurring earlier or later has adversely affected sowing and harvesting of crops, harvestable grains have been damaged. Moreover, there are reports that natural wetlands are shrinking in many parts of the region. Some ecologists have informed about appearance of more number of invasive species and changes in their distribution pattern in the region. Some have reported more number of diseases and pests in citrus species. One significant impact which many plant scientists agree to is the change taking place in the phenological phases in plants (ICIMOD, 2008).

More scientific work needs to be done on these aspects before drawing final conclusions. What needs to be remembered is that the common man's observations in rural or mountainous areas sometimes provide important evidences of changes in the local climate which are otherwise not pursued or indicated in scientific research. Moreover, in many cases the required climatological and other data data is not available at the desired scale to follow-up such local observations with scientific research.

Water and Climate Induced Hazards: Concerns for NE India

As a result of global warming and climate change, glaciers in the Himalayas are retreating at an average rate of 15 meter per year, consistent with the rapid warming recorded at Himalayan climate stations since the 1970s. In the Himalayan region alone 67% of the glaciers have retreated in the past decade, e.g. the *Gangotri* glacier has been receding at a rate of 28 meter per year. Under a warming environment the Himalayan glaciers are expected to melt faster leading to increased summer flows and flooding initially for a few decades followed by progressive reduction in flow as the river-feeding glaciers recede and disappear from the headstreams. Widespread water scarcity in the river basins like those of the Indus, the Ganga and the Brahmaputra is a serious consequence on the cards. Moreover, in case of glacier-fed rivers, glacial-melt runoff is seen to augment winter flow in the lean season. With glacial contribution deceasing over the years, in future lean season flow will decrease and water stress will increase in the Brahmaputra basin where large populations depend on agriculture for livelihoods. Glacial retreat in the Himalayas may lead to serious alterations in the hydrological regime of the Brahmaputra river system as the mainstream of the Brahmaputra (known as the *Yarlung Jhangbo* in Tibet, China) and some of its tributaries like the *Subansiri* and the *Jia-Bharali* are partly fed by snow-melt run-off. Projected increase in rainfall and accelerated summer flows may give rise to more intense flooding and flood hazards, but consequent retreat of glaciers may reduce flows in the long run.

Extreme precipitation events (heavy rain storm, cloud burst) may have their own impacts on the fragile geomorphology of the Himalayan part of the Brahmaputra basin causing more widespread landslides and soil erosion. The response of hydrologic systems, erosion processes, and sedimentation in the Himalayan river basins could alter significantly due to climate change. Two extremely intense cloud bursts of unprecedented intensity- one in the western Meghalaya hills and Western Arunachal Pradesh in 2004 produced two devastating flash floods in the *Goalpara* and *Sonitpur* districts of Assam bordering Meghalaya and Arunachal respectively causing hundreds of deaths.

The most recent examples of such flash floods originating from extreme rainfall are two events that occurred in the north bank of the Brahmaputra River and caused significant damage to human life and property. The first of the two events occurred during the monsoon season on June 14th, 2008 due to heavy rainfall on the hills of Arunachal Pradesh north of *Lakhimpur* District causing flash floods in the rivers of *Ranganadi*, *Singara*, *Dikrong* and *Kakoi* that killed at least 20 people and inundated more than 50 villages leading to displacement of more than 10,000 people. The other that occurred in the post monsoon season on October 26 affected a long strip of area of northern Assam valley adjoining foothills of Bhutan and Arunachal Pradesh causing flash flooding in four major rivers (all are tributaries of the river Brahmaputra) and a number of smaller rivers. This episode of flash floods caused by heavy downpour originated from the Tropical Depression ‘Rashmi’, (a depression over the West Central Bay of Bengal adjoining Andhra coast) and affected mainly the catchments of the rivers *Puthimari* (Assam-Bhutan border), *Jia-Bharali* (Assam-Arunachal Border), *Ranganadi* (Assam-Arunachal Border), and the *Subansiri*

(Assam-Arunachal Border). The *Puthimari* river flowing through *Kamrup* (Rural) district in Western Assam breached its embankment at Hohora and submerged about 11 villages along the highway at *Kendukona*. The National Disaster Response Force (NDRF) and Civil Defence teams had to jump into action to rescue the marooned people. The flood waters affected over 70,000 people in 70 villages and damaged standing paddy crops at the time of being harvested. Such extreme events, many of which go unrecorded due to lack of an adequate hydrometeorological gauging network, might be precursors of the weather anomalies to appear here in future.

The southern part of *Nagaon* district in central Assam valley and adjoining parts of *Karbi Anglong* form a rain-shadow zone where annual rainfall is as low as 800-1200 mm. Water scarcities are a potential constraint for the people living in this rainshadow zone and absence of effective irrigation systems or water harvesting practices adds to the vulnerability of the people. But what is of immediate concern is that rainfall in this zone is decreasing slowly as found in *Lumding* where rainfall is on the decline at a rate of 2.15 mm per year(Das, 2004). As a result water crisis might aggravate in this region in the coming years.

Floods have caused mayhem in the region, especially in Assam, every year causing tremendous loss to crops, infrastructure, economy, livelihoods and lives of the people. During the period of 45 years between 1953 and 2004, the seven states of the region suffered together a loss of Rs. 1729.2 crores due to flood damage to crops, houses and public utility while 1.25 million hectares of land were affected due to floods. In some years floods have affected more than 3.8 million hectares of Assam's total area of 7.8 million hectares (WB, 2007). Floods inundate at least 2,000 villages every year in addition to destroying other infrastructure. The problem is further exacerbated by riverbank erosion, which destroys about 8,000 hectares of riparian land along the Brahmaputra annually. Vast areas in the region have been affected by erosion e.g. 1 million hectares in Assam; 815,000 hectares in Meghalaya; 508,000 hectares in Nagaland; 108,000 hectares in Tripura; and 14,000 hectares in Manipur(Venkatachary et al., 2001). The estimated area of 386,000 hectares eroded since 1954 in the Brahmaputra valley has reportedly affected more than 90,000 families and about 2500 villages resulting in a loss of Rs. 3555 crores. Assam, however, is the worst sufferer in terms of direct economic damage. The total flood prone area in the Brahmaputra valley is estimated at 32 lakh hectares which account for 9.6 percent of the country's total. With more flooding predicted due to initial glacial melt and enhancement in monsoon rainfall, the hazards of flooding might increase in all proportions in the next few decades in terms of intensity, frequency, erosion potential, environmental damage, social disruption and economic costs. Add to it the increasing heavy rainstorms and the prolonged inundation of flooded areas, the flood scenario will become only worse in the near future.

Recession of glaciers caused by climate change have created more glacial lakes in the Nepal, Bhutan and Tibet Himalayas and increasing glacial lake outburst floods(GLOF) have caused more flash flooding in the Greater Himalayan Region in recent times. Increase in landslides have led to artificial damming of upland river courses and consequent bursting of the same have produced landslide dam outburst floods (LDOF) sending off waves of flash floods in downstream areas. GLOF and LDOF- induced flash flooding are ubiquitous in the Himalayan landscape and those occurring in the western as well as eastern Himalayas have already affected people in Himachal Pradesh, Uttaranchal, Arunachal Pradesh and Assam very severely. The LDOF that occurred in Bhutan when a landslide induced dam on the Tsatichhu river breached on July 10, 2004 forcing the authorities of the Kurichu Hydropower Project to open the gates of the dam and release the water to the Kurichu river that entered the Beki-Manas river system and flooded large parts of western Assam.

Similarly another LDOF-induced large flash flood caused havoc in the bordering areas of Arunachal and China in June 2000. A huge complex landslide occurred on April 9, 2000 in the valley of the Zhamulongba stream that produced about 300 million cubic meters of displaced debris comprising snow, ice, soil and rock, dammed the *Yigongzangbu* river - a large tributary of the *Yarlung Jhangbo* river (the upper-stream of the Brahmaputra), in the east of Tibet. The debris-flow originated reportedly from to heavy spring snow fall and rapid melting of snow and ice above the elevation of 5520 meter above sea level that occurred due to rapid rise in temperature in the summer and high precipitation in the steep mountain slopes of the Zhamulongba watershed. The dam failed on June 10, 2000 and caused havoc of flash flood in the river Siang with an estimated property losses of not less than a billion rupees, 30 deaths, more than 100 people missing, and more than 50,000 homeless in five districts of Arunanchal Pradesh, India (Li et al. 2001).Chinese scientists predicted the flash flood on the basis of rising of water level in the *Yigongzangbu* river in an ICIMOD publication of April 2000 But Indian authorities ignored the warning. Such disasters could only increase proportionately with degree of warming and change in the Himalayan climate (GBPIHED, 2001).

The Northeast Indian region is going to see massive distortion of its hilly landscape due to the construction of large dams as part of more than 168 hydropower projects in the next five decades (Goswami and Das, 2003). Government of India is also promoting large dam-based hydro projects in Bhutan. Given the high probability of increased heavy rainfall events, landslides, formation of GLOFs and LDOFs due to climate change in the Himalayan region, threats of flash floods will always loom large from the large dams in Arunachal, Bhutan and Sikkim for the downstream populations in Assam and North Bengal.

Vulnerability, Environmental Security and Sustainability

Environmental security, in the most rudimentary sense, refers to a state of mind that feels ‘secure’ i.e. feels free from threats, anxiety or danger that could originate from environment. Defined as development that meets the needs of the present without compromising the ability of the future generation to meet their own needs (WCED, 1987), *sustainable development* is an integrating concept embracing economic, social and environmental issues. Its three key components viz. economic growth, social equity and environmental sustainability have become ideal and important goals to be pursued by all nations. In the discourse of climate change and disaster risk reduction, sustainability and environmental security are highly relevant concepts that act as the guiding principles especially for in dealing with vulnerability, adaptation and mitigation. Reduction and mitigation of disasters functionally depend on the coping capacity of the vulnerable population. Poverty makes way for hazards becoming disasters. Poor people have less capacity and resources to respond adequately to the impacts of hazards and disasters, a fact that enhances their vulnerability and risk. Besides being determined by physical exposure to sources of hazards, vulnerability and risk of a community depends critically on its economic conditions and status of development.

Northeast India is vulnerable to water induced disasters because of its location in the eastern Himalayan periphery, fragile geo-environmental setting and economic underdevelopment. The powerful hydrological and monsoon regime of the region, especially the Brahmaputra and the Barak (Meghna) river systems are both a resource and a source of vulnerability. Moreover, the average state of economic development and growth in the northeast Indian region is lower than other parts of the country. The average per capita income of the region is approximately 30 percent lower than the national average. Assam and Manipur have the lowest per capita income in the region. The region has higher incidences of poverty, even when compared with states having similar average per capita income (WB, 2007). Increasing population and decreasing land productivity, relatively higher dependence on natural resources (e.g. forests) also are constraints for the region's environmental sustainability. A high degree of vulnerability to the water and climate induced disasters will increasingly make the region environmentally insecure in the future unless pragmatic interventions are made immediately. A set of holistic policy and programmes that integrate development goals with disaster risk management for the region as a whole is the need of the hour. The individual states of the region also need to have environmental policies (related to environment, forest, water, disaster management, natural resources management etc.) that conform to the objectives of long-term sustainability and security through integration of economic development and poverty alleviation with natural resources and disaster management.

Existing policies and development programmes have not yet recognised climate change and its potential impacts as factors that can significantly jeopardise the environmental and socioeconomic systems in the region. It is time for the national and regional planners to reconcile with the reality of climate change and take appropriate action for its mitigation. Reliable assessment and mapping of vulnerability and risk and promoting appropriate adaptation strategies are also equally important to ensure mitigation of the water and climate induced vulnerability in the region. Immediate steps should be initiated by state Governments in the NE region through appropriate policies and practices in water, forest, environment and disaster management to make environmental and climate concerns inbuilt in all development activities. Besides proper scientific appraisal of the climate change impacts, capacity building of the vulnerable population to reduce risks and adapt to climate-driven changes in natural ecosystems and human societies are the urgencies of the hour.

Reference:

Bogardi, Janos, J. (2004). Hazards, risk and vulnerability: a new look on the flood plains. Paper presented in the International Workshop and Symposium on Water Hazard and Risk Management. 20-23 January. Tsubuka City and Tokyo.www.ehs-unu.org

Das, P.J. and Goswami, D.C. (2003). Long-term variability of rainfall over northeast India. Indian Journal of Landscape Systems and Ecological Studies. 26(1):1-20.

Das, P.J. (2004). Rainfall Regime of Northeast India: A Hydrometeorological Study with Special Emphasis on the Brahmaputra Basin. Unpublished Ph.D. Thesis. Gauhati University

GBPIHED (2001). ENVIS Bulletin: Himalayan Ecology & Development, Volume 9, No. 2, 2001. G.B. Pant Institute of Himalayan Environment and Development.

Goswami, D.C. and Das, P.J. (2003). The Brahmaputra River, India: The eco-hydrological context of water use in one of world's most unique river systems. Ecologist Asia. Special issue on large dams in northeast India- Rivers, forests, people and power. 11(1):9-14.

ICIMOD (2008). Recorded proceedings of the two day 'Climate Change and Vulnerability of Mountain Ecosystems in the Eastern Himalayan Region, North-East India & Bhutan Stakeholders Workshop' 11-12 March, 2008, Shillong. Organised by International Centre for Integrated Mountain Development Kathmandu, Nepal

IPCC (2007a). Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2007b). Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

ISDR (2002). Living with risk (a global review of disaster reduction initiatives). International Strategy for Disaster Reduction. Preliminary version, Geneva http://www.cig.ensmp.fr/~iahs/maastricht/w4/w4706.htm

Kron W. (2003). High water and floods: resist them or accept them? In: Schadenspiegel (Losses and loss prevention), 46th year. No.3. 26-34. Munich Re Group, Munich

Li Tianchi, Pingyi Zhu and Chen Yongbo (2001). Natural Dam Created by Rapid Landslide and Flash Flooding from the Dam Failure in Southeastern Tibet, China, 2000. Unpublished paper presented in the Regional Workshop on Water-Induced Disasters in the Hindu Kush Himalaya Region, 11-14 December 2001 in Kathmandu, Nepal.

Mirza, M.M.Q., Warrick, R.A., Ericksen, N.J. and Kenny, G.J. (1998). Trends and persistence in precipitation in the Ganges, Brahmaputra and Meghna river basins. Hydrological Sciences- Journal-des Hydrologiques. 43(6):845-858.

Pant, G.B. and Rupa Kumar, K. (1997). Climates of South Asia. John Wiley and Sons, New York. 320p.

Plate, E. (2002). Environment and Human Security. Results of a workshop held in Bonn on June 23-26, 2002. In: Plate, E. (Ed) Environment and Human Security. Contributions to a workshop in Bonn, Bonn, Germany.

Venkatachary, K. V., K. Bandyopadhyay, V. Bhanumurthy, G. S. Rao, S. Sudhakar, D. K. Pal, R. K. Das, Utpal Sarma‡, B. Manikiam,, H. C. Meena Rani and S. K. Srivastava(2001). Defining a space-based disaster management system for floods: A case study for damage assessment due to 1998 Brahmaputra floods. Current Science, Vol. 80, No. 3. pp. 369-377.

WCED (1987). Our Common Future: Report of the World Commission on Environmental and Development. Oxford University Press. New York.

WB (2007). Development and Growth in Northeast India: The Natural Resources, Water, and Environment Nexus. World Bank Report No. 36397-IN. The International Bank for Reconstruction and Development/ The World Bank. Washington DC, USA.

Wisner, B. (2002). Who? What? Where? When? In an Emergency: Notes on Possible Indicators of vulnerability and Resilience by Phase of the Disaster Management Cycle and Social Actor. In: Plate, E. (Ed), Environment and Human Security: Contributions to a Workshop in Bonn, Bonn, Germany

PS1: An unreferenced and edited version of this article was published in the January-March, 2009 issue of the Development NE, a bulletin of the North East Development Forum, New Delhi.

PS2: This article may be referred to as
Das, P.J. (2009). Water and climate induced vulnerability in northeast India: Concerns for environmental security and sustainability. WATCH Research Report 1. AARANYAK. Guwahati, Assam, India. www.aaranyak.org

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