Draft Report - Assam State Action Plan on Climate Change

(Prepared by The Energy and Resources Institute, New Delhi)

Assam State Action Plan on Climate Change, 2012 - 2017

Prepared for

Department of Environment & Forest,
Government of Assam

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PART A CONTEXT

Chapter 1 Assam's Development Scenario

1.1 The geo-physical situation

Assam, situated at the foothills of the eastern Himalayas, is the largest state in northeast India and lies in the middle reach of the river Brahmaputra and Barak. The State accounts for nearly 2.4% of India's total geographical area The Brahmaputra basin covers an area of 5,80,000 sq. km out of which 70,634 sq. km falls within Assam. The land has uneven topography, full of hills, plains and rivers. Except for a narrow corridor running through the foothills of the Himalayas that connects the state with West Bengal, Assam is almost entirely isolated from India. This state is bordering Arunachal Pradesh in the east, West Bengal, Meghalaya, Bangladesh in the west, Arunachal Pradesh, Bhutan in the north and Nagaland, Manipur, Mizoram, Meghalaya, Tripura in the south. Its longitude lies at 88.250E to 96.00E and latitude at 24.50N to 28.00N and temperature varies from 60C to 380C. The humidity that is brought into Assam by the southwest monsoons, shower an average annual rainfall of 120 inches or more on the Brahmaputra valley and the surrounding region. The monsoons are Assam's life line; creating a bio-diversity that can compete with the equatorial rain-forests (State profile, Ministry of Health and Family Welfare, 2009). The topography and the warm and humid climate are conducive to plant and vegetation growth. Assam is home to 51 forest and sub-forest types, and the confluence of diverse patterns of vegetation (Assam Human Development Report, 2003).

The Brahmaputra River flows through Assam from east to west over a length of approximately 650 kilometers. Its main branch originates in the Tibetan plateau, flowing from west to east as the Tsangpo River, and then turns south through the eastern Himalaya as the Dihang River to enter Assam, where it is joined by other branches to form the Brahmaputra. The Barak River rises in the Indian state of Nagaland at an elevation of approximately 2,300 meters and passes through the Manipur Hills of Manipur state over a river length of nearly 400 kilometers. It then flows generally westward from Lakhipur through the Cachar Plains region of Assam over a river length of approximately 130 kilometers to enter Bangladesh near Bhanga (NHC, Background paper, 2006). Each flood season, the Brahmaputra and its tributaries forsake their earlier channels to cut new swathes through the soil. As the water recedes, alluvial deposits remain in the river, giving rise to sandy islands. Some of these islands are very large, and the annually enriched soil has attracted cultivation and semi-permanent settlement. There is a distinct monsoon season in which a large part of the annual rainfall is concentrated. There are also two months of cyclonic activity preceding the monsoon, and rainfall at other times of the year as well.

1.2 Demographic profile

According to the 2001 census, Assam's 26.64 million people account for 2.59% of the country's population with its population density being marginally higher than the average density of the country (Assam Human Development Report, 2003). In most of the decades during the 20th century, the population of the state was well above the national average, and this has been attributed to large scale migration. But, this trend seemed to have reversed in the last decade with a decline in the decadal variation as opposed to that of the country (Assam Human Development Report, 2003). Migration, still poses as a disturbing and alarming situation in the state with its continuation even in normal time (Economic Survey

of India, 2009-10) There had been adverse sex ratio disparities in Assam at the beginning of the 20th century, while, during the recent decades this trend has been improving with 932 females for every 1000 males compared to 933 to 1000 in the country (Assam Human Development Report, 2003).

Given below in the table is the demographic profile of Assam as per the 2001 census:

Population	26655528
Male	13777037
Female	12878491
Rural	23212268
Urban	3439240

Source: Assam Development Perspective, 2011

1.3 Agriculture and natural resource systems

Assam is blessed with fertile soil and a climate conducive to agriculture. The economy of the State continues to be predominantly agrarian and the dependence of rural labour force on agriculture and allied activities was nearly 53 per cent as per the 2001 population census (Economic Survey, 2009-10). Agriculture accounts for more than a third of the state domestic product. The total production of food grains and other crops have recorded an increase in the last fifty years, but the per capita food grain has showed a decline. There is also evidence of productivity declines in recent years of major crops and particularly rice (upto 2006-07). A number of factors constrain low productivity in the agricultural sector, most important being the frequent occurrences of floods. The shift to modern technologically advanced and market oriented agriculture has been slow in Assam.

Assam is a treasure trove of enormous forest wealth and biodiversity, apart from a rich heritage of cultural diversity, traditions and practices that are closely linked to the State's immense natural resources. Assam lies within the Eastern Himalayas, part of the Indo-Burma Biodiversity Hotspot (Myers 2000). This region's lowland and montane moist to wet tropical evergreen forests are considered to be the northernmost limit of true tropical rainforests in the world (Proctor et al. 1998).The Eastern Himalaya and the Assam plains have been identified as an Endemic Bird Area by the Royal Society for Protection of Birds, (Bibby et al.1992). The global distribution of 24 restricted-range species is limited to the region. The richness of the Eastern Himalayan region's avifauna is a function of the diversity of habitats associated with a wide altitudinal range and its unique location at the confluence of the Indo-Malayan, Indo-Chinese and Indian biogeographical regions. In fact North East India including Assam supports some of the highest bird diversities in the world, believed to be second only to the Peruvian Andes. Assam also lies along two migratory routes of birds - the Central Asian flyway and East Asian-Australian flyway. Assam falls within a mega biodiversity zone of the world. Recent wildlife inventories and surveys are unearthing

several new species of fauna from Assam, especially reptiles and amphibians. For example, Smith's litter frog (Leptobrachium smithi), identified in 1999, is one of five new frog discoveries from of Assam, and was reportedly discovered in the Mayeng Hill Reserve Forest and Garbhanga Reserve Forest, Kamru District, Assam (WWF, 2009).

Assam is famous for its megafauna including the rhino (*Rhinoceros unicornis*) golden langur (*Trachypithecus geei*), hoolock gibbon (*Hoolock hoolock*) and other highly endangered species like the pygmy hog (*Porcula salvania*), hispid hare (*Caprolagus hispidus*) and the recently rediscovered white winged wood duck (*Cairina scutulata*) A recent camera trapping exercise in the last remaining lowland rainforests of Jeypore-Upper Dehing-Kakojan (ca 570 sq. km) in Assam, indicated that these forests harbor the highest number of wild cat species in the world including the clouded leopard (*Neofelis nebulosa*), marbled cat (*Pardofelis marmorata*), and golden cat (*Catopuma temminckii*), as well as four relatively widely distributed species — tiger (*Panthera tigris*), leopard (*Panthera pardus*), leopard cat (*Prionailurus bengalensis*), and jungle cat (*Felis chaus*) (CEPF, 2010). That a single rainforest can hold such a high number of wild cat species, and the recent discovery of several species new to science suggests the enormous biodiversity of the forests of Assam that still needs to be inventoried and discovered.

Assam's faunal wealth is matched by the diversity of its plant resources. The North East region has been identified by the Indian Council of Agricultural Research (ICAR) as a centre of rice germplasm (Chatterjee et al. 2006) and is a center of origin of commercially important plants such as banana, citrus, Zizyphus and tea (Department of Environment and Forests, Undated). The National Bureau of Plant Genetic Resources (NBPGR) has highlighted the North East region as being rich in wild relatives of crop plants. Assam is also very rich in medicinal plants and many other rare and endangered taxa and is characterized by high levels of endemism. Assam's richness of flowering plants is estimated at about 3010 (Chatterjee et al. 2006). About 293 species of orchids have been reported from Assam representing 44.39% of North East species and 24.42% of species occurring in India. Assam also has much bamboo (41 species) and cane species diversity (14 species) including some species reported only from Assam. As many as 952 plant species of medicinal value are found in Assam (Department of Environment and Forests, Undated).Broadly speaking the forest resources are divided into the following types Tropical Wet Evergreen forests, Tropical Semi Evergreen forests, Tropical Moist Deciduous forests, Sub-Tropical Broadleaf Hill forests, Sub-Tropical Pine forests, Littoral and Swamp forests and grasslands and savannahs (Champion and Seth, 1968).

Assam harbours at least 3500 freshwater wetlands covering 1012.29 sq km that, according to satellite data, constitute 1.29 per cent of the total geographical area of the state. Most of these wetlands are in the floodplains of the rivers Brahmaputra and Barak and their tributaries and include *beels*, swamps and marshes. Two species of endemic aquatic plants, two critically endangered, seven endangered, and 26 vulnerable species of fishes, five near threatened, six vulnerable species of freshwater turtles and 133 species of birds have been recorded from the 35 major wetlands in Assam (Chatterjee, 2006).

These wetlands are home to a variety of fishes and other aquatic fauna; they act as ideal natural habitat for both domestic and migratory birds; they make up the shortage of

irrigating water into the agricultural fields during the lean season; and can also act as reservoirs of flood waters. However, the wetlands of Assam are fast shrinking due to both natural and anthropogenic causes. The extensive and uncontrolled growth of water hyacinth, and the raising of dykes and embankments along the river banks are thought to be the main causes of the deteriorating condition of these wetlands. These wetlands are subjected to harsh organic processes caused by debris from floating vegetation and silt carried by rain water. Another alarming cause is rampant human settlements, industrial developments and other economic activities that disturb the ecological balance and lead to the loss of these wetlands (Environment Information System-Assam, ASTEC, 2010).

The State possesses an estimated 320 million tons of coal reserves, oil and natural gas reserves, sufficient to sustain current production levels for at least another fifty years, and a vast, though largely untapped, potential for power generation.

1.4 Industry and infrastructure

Assam is the most industrialized state of the north east region, but industrial growth and diversification is still hampered by poor infrastructure, power and transport facilities, the geographical isolation of the region, and the lack of well developed markets. The Tea industry which is about 170 year old, plays a vital role in the State as well as national economy. The total area under tea cultivation is accounting for more than half of the country's total area under tea. The tea production in Assam constitutes more than 50 percent of the total production of the country (Economic survey, Assam, 2009-10).

Assam has ample scope for Bamboo based industry like paper manufacturing industry since this region has highest concentration of bamboo i.e around 60 percent of total bamboo of the country. Sericulture is a major cottage industry and the State has achieved the right of "Geographical Indication" in production of "Muga silk".

The power supply position in the State is not much encouraging since last few years. The per capita availablity of power in the State is 116 Kwh in 2006-07. In order to meet the shortage of power supply, the State continued to purchase power from other state and private power traders. Assam is also lagging behind most of the other states in the country in rural households electrification by electrifying 77 per cent villages till date, out of which 20 per cent of the households in the villages have electric supply, as per report available.

1.5 Exposure to hazards

Assam is highly vulnerable to floods, river bank erosion, sand casting, landslides, cyclonic storms. The exposure to such hazards is also aggravated because of the location of the State in the northeastern region which is one of the most seismically active regions in the world. Assam is said to receive high torrential rainfall ranging from 248cm to 635cm which also contribute to the flooding of the Brahmaputra River. The encroachment of a large number of wetlands that serve as natural reservoirs has decreased the retention capacity of the system causing floods to rise. The easily erodible geological formations also contribute to river expansion and increased sediment influx of the river.

An overall estimated 92.6% of cultivated land or 3.15 mha of the area is prone to floods in the valley (SNC, 2010). Tenth five year plan indicates a crop loss of value of Rs.14559.95 lakhs. Flood damages to crops, cattle, houses and utilities from 1953 to 1995 is estimated at 4400 crore, with a peak of 664 crore in a single year (Staff College Report, 2005). An

estimated 8,000 ha of riparian land are destroyed annually due to river bank erosion (SNC, 2010). Sand deposition /casting i.e. accumulation of enormous dunes of sand are seen to be more severe and devastating since the mid 1990's especially in the northern banks of eastern Brahmaputra Valley. This had rendered fertile lands to be fully unproductive thus displacing people and causing loss of productivity and marginalization. It has increasingly caused deterioration of wetlands and farmlands (ICIMOD, 2009). Landslides, causes blocking of courses, bursting of these temporary bunds causes devastating floods downstream. It also acts an obstacle in the flow of the river, which upset regime of Brahmaputra Basin (Staff College Report, 2005) Damming of the tributaries of the Brahmaputra causing liquefaction damage where the river enters the plains. Landslides also increase the detritus content of the river causing increased water flow. The events of cyclonic storms have been observed to be more frequent in the western parts of Assam especially during monsoons causing colossal losses to lives and property (Staff College Report, 2005).

1.6 Economic vulnerability

Assam remains one of the poorest states in India. Despite recent acceleration of its economic growth, disparity against the national average income has still been widening (Asian Development Bank, 2010). In terms of poverty Assam has more than a third of its population (36.09%) under the poverty line (Assam Human Development Report, 2003). The percentage of poor in Assam is the highest amongst the north eastern states. Poverty in Assam is more widespread in the western, southern and the hill districts. Income, employment and poverty are three interrelated and central areas of concerns for Assam (Assam Human Development Report, 2003).

There is a urban rural divide; two out of five people in rural areas are likely to be below the poverty line, while in urban Assam the incidence is less than one in ten (Assam Human Development Report, 2003). The state of Assam also has a Human Poverty Index calculated on the basis of a sample study. According to the Human Poverty Index, 1999 the district Karbi Anglong has the highest HPI value of 33.52% projecting that this district has the highest number of people living in poverty (Assam Human Development Report, 2003).

Chapter 2 The Climate Change Challenge

2.1 Observed Climate and Climate Change Projections for Assam

2.1.1 Observed Climate Variability and Trends in Assam

2.1.1.1 Rainfall

The region receives rainfall both during the summer and winter months from the south-west monsoon and the north-east monsoon. It forms the basis for monsoon onset and its prevalence over other parts of India due to the synoptic features prevalent over the state. **The region is characterized by high rainfall but analysis of long-term trends in the annual rainfall indicates a slight decline in the total rainfall received in the region (Das, 2004; Mirza et al., 1998; Tiwari, 2006, ASTEC, 2011).**

The pre-monsoon and post-monsoon thundershowers are very dominant over this region due to orography and the humidity available for convection. Kandalgaonkar et al 2005 in their study to address the relationship between thunderstorm activity and rainfall over different homogeneous regions of India also showed that over the North Eastern **region the probability of association of thunderstorm with rainfall is quite high when compared to other regions** (Figure 2.1). **Also months with high rainfall have been observed to have more number of thunderstorms. Thunderstorms in post-monsoon season have been observed to be with higher intensities than during the pre-monsoon season.**

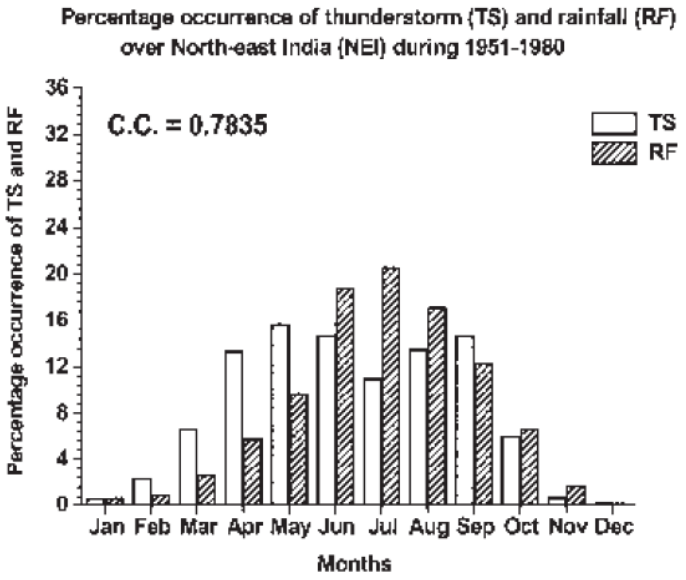


Figure 2.1: Percentage occurrence of thunderstorm and rainfall over North-east India during 1951-1980, from IMD (Kandalgaonkar et al 2005).

A comparison study of extreme events and floods associated with summer monsoons, in the Western Ghats and Assam has been studied by Jamir et al (2009), that shows that the **chances of prevalence of high floods has been observed when monsoon rainfall has been**

high over these regions. Also, Deka et al (2009) using the rainguage stations in North-eastern Indian region showed that Cherrapunji and Mohanabari had the highest mean and standard deviation and coefficient of variation and the probability of extreme events in rainfall can occur where the mean, standard deviation and coefficient of variation are high (Table 2.1).

Table 2.1: Main characteristics of the rain guage stations in North-East India from 1966 to 2007 from Regional Meterological Center, Guwahati (Deka et al 2009).

Stations	*Mean*	*SD*	*CV*
Cherrapunji	573.6167	172.6664	.3010
Guwahati	104.9786	35.2915	.3362
Imphal	82.7619	29.5122	.3566
Mohanbari	142.9476	86.7992	.6072
North Lakhimpur	149.1619	38.1247	.2556
Pasighat	225.3238	98.8148	.4385
Shillong	144.5048	51.3595	.3554
Silchar	153.2524	56.4452	.3683
Tezpur	103.7476	27.3783	.2639

Thus, it is essential that we need to address the extreme events in rainfall and its influence on the other socio-economic factors over the region.

2.1.1.2 Temperatures

The 20th century has observed a warming trend of 0.51^{o}C in India with accelerated warming observed from 1970 onwards. **The region has experienced increase in the annual mean maximum temperatures, with increase at the rate of +0.11°C per decade and annual mean temperatures at a rate of 0.04°C per decade in the region.**

2.1.2 Model Projections

There are very few studies that have done a thorough analysis of the trends of changes in the climate for the region that can be used to draw conclusions. Projections provided by experts on changes in the climate, has been done using different outputs either available at coarser resolution or based on single model outputs for a particular scenario. These studies though indicative in the very broadest sense of the changes that are likely in the climate does

not help in capturing the uncertainties associated with the various projections, indicating the need for further research on these aspects. A few studies that are available conclude as follows (see Box 2.1);

Box 2.1: Available studies on projections for the NER

1) Kulkarni *et al*., 2010 using the IPCC-AR4 model outputs over the Indian region concluded that there is a substantial increase in the amount of summer monsoon season rainfall over the NER until 2100, these models had a coarse resolution and hence the significant spatial variability were not much predominant over the region.

2) A separate study by Rajendran et al (2008) using a high resolution MRI general circulation model at 20km mesh grid, showed that the monsoon variability is well represented in the baseline and the future changes over the region shows reduction in rainfall over the Assam region for SRESA1B scenario, whereas the extreme events were found to increase.

3) The regional climate model assessments over Indian region using HADRM2 suggests that India's initial national communication (NATCOM, 2004) using the Regional climate projections of HadRM2 suggests that the seasonal mean rainfall (over 2080s time period) increases over the NER, and also there is a possibility of increase in number of rainy days over the region (NATCOM, 2004).

4) Kumar et al 2006, in their study using the PRECIS (Providing REgional Climate for Impact Studies) model showed that the temperature are likely to increase by 2.5^{o}C- 4^{o}C in A2 over the Indian region, with pronounced warming over the Northern and northeastern parts of India. The percentage increase in rainfall is also suggested to increase over the Assam region during 2080s when compared to 2030s and 2050s.

High resolution regional climate model (PRECIS) simulations using lateral boundary forcing from three QUMP (Quantifying Uncertainties in Model Projections) runs in a recent report prepared by MoEF for the A1B scenario for 2030's indicates an all-round warming over the Indian Subcontinent (figure 2.2).

The annual temperatures are set to increase from a minimum of 26.8^{o}C to a maximum of 27.5^{o}C in the 2030's. The rise in temperature with respect to the 1970's (climatology) shows a range between 1.7 to 1.8^{o}C. Seasonal temperature for all the three QUMP (stands for Quantified Uncertainty in Model Projections) simulations also projects a rise from 1.5 to 2.2^{o}C, with the monsoon months of June, July, August and September showing

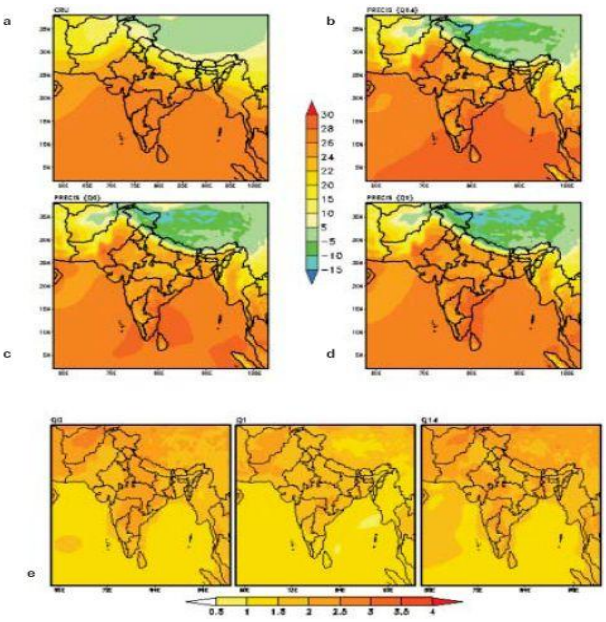


Figure 2.2. (a,b,c and d): Mean annual surface air temperature climatology based on observations and simulated by three PRECIS runs compared with the observed climatology for baseline period (1961-1990);

(e): Projected changes in the annual surface air

maximum rise amongst all the seasons (Figure 2.2).

The projections of all-India summer monsoon rainfall indicate a 3% to 7% overall increase in the 2030's with respect to the 1970's. The projected mean annual rainfall for the NER is found to vary from a minimum of 940±149mm to 1330 ±174.5 mm. The increase with respect to 1970's is by 0.3% to 3%. The north-east also show a substantial decrease in rainfall in the winter months of January and February in 2030's with respect to 1970's with no additional rain projected to be available during the period March to May and October to December. In fact, recent data indicates the same pattern. However, the monsoon rainfall during June, July and August is likely to increase by 5 mm in 2030's with reference to 1970's. Presently, intensity of a rainy day is more in Western Ghats and North-East India. The intensity of the rainy days increases in a more warming scenario in Q14 with respect to simulations Q0 and Q1 (INCCA, 2010).

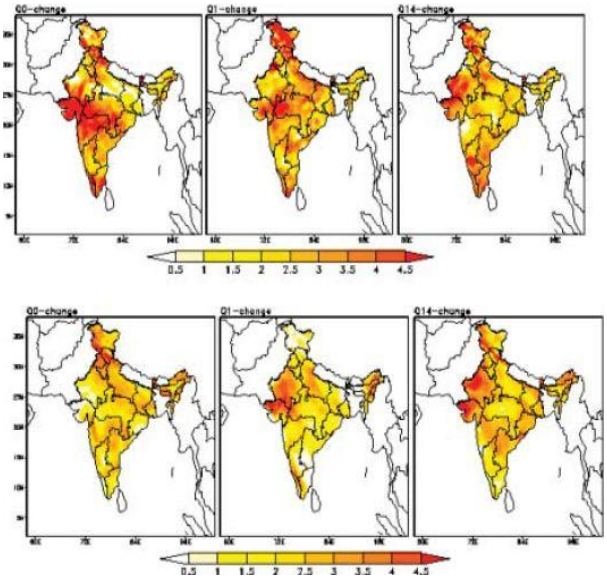


Figure 2.3: Changes in the minimum (upper panel) and maximum temperatures (lower

2.1.3 Summary

Temperature variations (Summarised INCCA Report, 2010)

1. The annual temperatures are set to increase from a minimum of 26.8 degree C to a maximum of 27.5 degree C in the 2030's
2. The rise in temperature with respect to the 1970's (climatology) shows a range between 1.7 to 1.8 degree C
3. Seasonal temperature for all the three QUMP (stands for Quantified Uncertainty in Model Projections) simulations also projects a rise from 1.5 to 2.2°C, with the monsoon months of June, July, August and September showing maximum rise amongst all the seasons

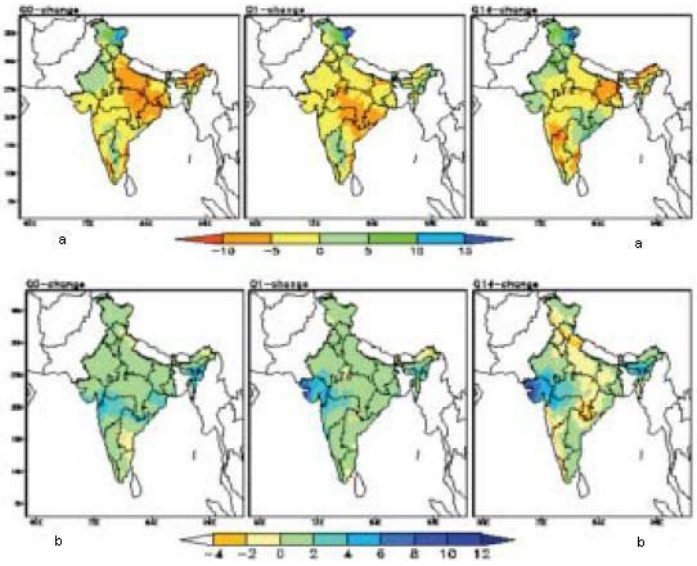


Figure 3. (a) Change in frequency of rainy days,

(b) Change in intensity of raindays. Both changes are

Rainfall variations (Summarised INCCA Report, 2010)

1. The mean annual rainfall is projected to increase in the region and found to vary from a minimum of 940±149mm to 1330 ±174.5 mm.
2. Rate of increase in rainfall over Assam while projected to increase, is projected to be slightly lesser when compared to the state of Arunachal Pradesh and some parts of North Assam adjoining Arunachal Pradesh.
3. On an overall the number of rainy days is projected to decline in Assam, but intensities would increase.

From the observations, as concluded an increase in the rainfall in the pre-monsoon and post-monsoon months might be associated with increased number of thunderstorms in the region.

Extremes

1. Changes in rainfall patterns and its increasing variability in the future may have some regions experiencing scarcity of rainfall and others an increase. Drought like conditions might prevail given the climatic variations expected.
2. Projected increase in rainfall, rainfall intensities and accelerated summer flows may produce more frequent conditions of floods, flash floods in the Brahmaputra valley.

Uncertainty

- Increased number of observations is essential for further validation of models and climate variability over the region.
- Changes in extreme events of rainfall and temperature might have direct or indirect impacts on different sectors in the region.
- Changes in hydrological response of the basins including impacts on glaciers.
- Land use changes and development trends.

Table 2.2: Summarised projections of likely changes in the climate for Assam for 2030s (INCCA, 2010)

S. No.	Variables	Observed changes	Projected changes	Impacts	Uncertainties	Knowledge gaps
1	Temperatures	Increase	Increase	All natural and human systems	High degree of confidence	Invest in research
2	Total Rainfall	Decrease	Slight increase	All natural and human systems	Degree of confidence low	Invest in research
3	No. of rainy days	-	Decrease	All natural and human systems	Degree of confidence low	Invest in research
4	Rainfall Intensities	High	To increase further	All natural and human systems	Degree of confidence low	Invest in research

2.2 Impacts of climate change in key sectors of Assam

Like the rest of the northeast region of India, Assam is extremely vulnerable to climate change. Assam has a high reliance on agriculture that is likely to only increase given its growing population. Climate change poses additional challenges as higher temperatures increase the need for irrigation and the risk of heat stress or crop failure. Changing weather patterns and rising temperatures leave farmers vulnerable to crop losses. Additional precipitation increases the risk of crop flooding.

Climate change will also negatively impact the water resources sector by increasing freshwater scarcity, which is already a problem for Assam in the summer. The northeast region has the highest forest cover in India, which provides a number of adaptive advantages. Forests can reduce soil erosion and runoff, regulate flooding and temperature and mitigate climate change. However, Assam has the lowest forest cover in the region at 35.5% and reports indicate that it is decreasing. This has serious implications for the disaster management sector.

Every year, Assam suffers from devastating floods. These are likely to become more frequent due to increasing precipitation, more frequent storm events, deforestation and a growing population living along Assam's biggest and most flood-prone river, the Brahmaputra.

Finally, studies indicate that the effects of climate change will be felt most strongly by the poor.[1] Poverty is a major challenge for Assam. The poverty rate is 36%, higher than the Indian national average of 27% and one of the highest in the northeast.[2] The per capita income is rps. 15,661, 40% lower than the Indian average.[3] The combination of climate-related agricultural stress, a growing population more frequent disasters and Assam's poverty may increase the strain of Assam's already stressed public health system, food distribution programs and public assistance schemes.

Assam Key Vulnerability Indicators[4]	
% Living under Poverty Line	36.09
% Living in Rural Areas	87.1
% Dependent on Agriculture	53
% Literate	63.3
% Forest Cover	35.5

[1] Mendelsohn, R., A. Dinar and L. Williams. 2006. The Distributional Impact of Climate Change on Rich and Poor Countries. *Environment and Development Economics* 11: 159-178.
[2] India Census, 2001. Available from www.censusindia.net.
[3] Ministry of Development of North Eastern Region & North Eastern Council. 2008. North Eastern Region Vision 2020
[4] Unless otherwise noted, data is from the 2001 India Census, Available from www.censusindia.net.

2.3 Assam's Emissions Profile

Obtaining an accurate and recent emission profile for the State is a challenge given the lack of available data. Approximate indications for which mitigation inferences can be made from can be based on early data, yet determining a more recent emissions inventory, possibly based on modelling projections should be at the paramount of the State's Action Plan which could be done in conjunction with quantifying the mitigation identified in the latter sections of this document in a bottom-up manner. According to estimates conducted in 1990, the State's total GHG emissions from the anthropogenic activities amounted to 19.9 MT carbon dioxide equivalents (CO_2e). This was comparatively low as compared to most of the other states and ranked 14th while accounting for just under 2% of India's total emissions. The estimates further saw a modest increase in 1995 and amounted to 20.9 MT CO_2e. However, the state still ranked 14th and accounted for only 1.7% of India's total emissions. The larger contributing districts in Assam by percentage of the total emissions in 1990 included; Dibrugarh (10.8%), Kamrup (9.6%), Nagaon (8.2%), Sibsagar (8.0%), Sonitpur (6.2%), Kokrajhar (5.3%), and Barpeta (4.7%. Similar trends are observed in 1995. These estimates were made in the context of India's first National Communication to the UNFCCC. The only other estimates or updated information on the GHG emissions is for the year 2007 as part of the INCCA publication, India's greenhouse gas emissions 2007[5]. These estimates suggest that there is about 3 % increase (CAGR) in 2007 as compared to 1994[6]. However, the study does not give state-wise estimates therefore similar estimates for Assam is not available. Some of the recent trends in activities that contribute to the GHG emissions are discussed in the following section.

2.3.1 Energy sector overview

2.3.1.1 Energy

As of 2007-2008 Assam has an installed electricity capacity of just over 1000 MW (BEE 2009); however CEA estimates the installed electricity capacity at 700 MW. This may be primarily due to plant retirements. The 2007-2008 total consumption was listed as 2544 GWh with peak demand is at 848 MW with the state operating at a peak deficit of -9.7% (BEE 2009). Based on sector-wide break-up of energy sales in 2007-2008, the largest sectors include industrial with 53% and domestic use with 27% (BEE 2009). Compared to the rest of the nation, Assam has relatively lower electricity consumption per thousand population of 122365 kWh (all-India value being 50662 kWh), as well as electricity consumption per sq. km being 46394 kWh (all-India value being 175818 kWh) based on 2007-2008 values. The per capita consumption of electricity for the same period is 188 kWh compared to the all-India value of 717 kWh.

The current energy mix based on CEA 2008 values of Assam installed electricity capacity sees the primary energy supply come for gas 59%, hydro 22.4%, steam 13.4%, diesel 4.6% and renewable sources which includes solar, wind, microhydel and biomass totaling 0.5%. Thermal power for electricity generation from fossil fuels comes exclusively from natural

[5] INCCA foreward
[6] INCCA report

gas being 1125 GWh (44% of total consumption), which interestingly has one the lowest plant load factors (PLF) in India of 20% when compared to the all-India PLF of 72%. This would suggest a lower level of efficiency within existing thermal power generation capital, highlighting it as an area for significant improvement, or a refocusing of electricity generation towards the other available option.

2.3.1.2 Transport

Due to the recent trends observed in the developmental growth, population growth and urbanisation, there is an increased demand in the transportation services. In the absence of efficient public transport system, private vehicles have grown at a rapid pace in the state. Total number of vehicles in the state increased about 120% during 2001-09 while only during 2008-09 registration of vehicles recorded 23% increase. These vehicles mainly consume non-renewable fossil fuels, and are a major contributor of green house gases, particularly CO_2 emission. Such trends are indicative of increased fuel demand and vehicular emissions. The total commercial energy consumption in the transport sector is estimated to be huge and includes fuel such as diesel, petrol, CNG, LPG etc. In India, transport sector emits an estimated 258.10 Tg of CO_2, of which 94.5% was contributed by road transport (2003–2004) . Among all the states and Union Territories, North eastern states including Assam do not contribute significantly of the India's emissions from the road sector, given that only six states (Maharashtra, Tamil Nadu, Gujarat, Uttar Pradesh, Rajasthan, Karnataka) account for 51.8% of the CO_2 emissions from road transport (Ramachandra & Shwetmala, 2008). Further, number of classified towns increased from 93 in 1991 to 125 in 2001 and percentage urban population increased from 11 to 13 % in same period, suggesting a directional increase in number of vehicle requirements in future. While it is alarming that the rate of growth of urbanisation in Assam in period (1951-2001) was faster than that of rest of India, Assam (12.72 % in 2001) is still much less urbanised. Hence, it is also indicative of opportunities that the state has to take sustainable and low carbon development pathway unlike the already developed regions.

2.3.1.3 Residential/ commercial

The emissions profile and growth of the residential and commercial sector, while lacking in sector specific emissions data, is directly linked to the rapid population and urbanization growth seen in the state. The rate of urbanization during 1951-2001 was faster than that of India. Yet the level of urbanization in the state is comparatively small at only 12.7% based on 2001 figures. This is reflected when looking at the total energy use from the sector for both buildings and municipalities. 2007-2008 BEE estimates show that primary energy consumption was only 330 million kWh (9% of total) and 43 million kWh (1% of total) for buildings and municipalities respectively. The vast majority of the energy use and therefore the emissions from buildings come from smaller buildings with connected loads of less than 500kW, approximately 94%[7]. Such buildings have an additional challenge in adopting mitigation measures likely having higher costs, thereby leaving a relatively potion of the buildings available for low-cost mitigation options.

[7] BEE - Bureau of Energy Efficiency (India), *State-wise detailed assessment of electricity conservation potential in some key sectors of the economy*, Government of India, 2009.

Energy used in residential sector is primarily used for cooking, lighting, heating and household appliances. For cooking, LPG is the primary source in the urban areas while in rural areas biomass fuels such as fuel wood, crop residues, and animal dung continues to be dominant fuel. In the commercial sector, key activities include lightning, cooking, space heating/cooling, pumping, running of equipments and appliances. Sources of energy include grid based electricity, LPG, kerosene, diesel, charcoal and fuel wood

2.3.1.4 Industry

As mentioned above in the energy sector, industrial use of energy is one of the largest uses of energy with 1928 million kWh, accounting for 53% of direct energy sold. In addition to these indirect emissions from the industrial sector which would comprise the largest portion of emissions, Assam would also have other direct emissions based on industrial processes. The main industrial sectors include; cotton and jute textiles, petroleum refining, petroleum products, and to a lesser extent fertilizers and pesticides, cement, pulp and paper, iron and steel and aluminum products. In addition to the above, tea is one of the state's largest sectors, and while not high in terms of energy intensity as a major sector, it is considered as a significant energy intensive SME cluster. BEE estimates that there are 926 units within the sector which could generate annual energy savings of around 115 million kWh (BEE 2009).

2.3.2 **Agriculture and Livestock**

India's agriculture sector emitted 334.41 million tons of CO2 equivalents, of which enteric fermentation constituted 63% of the total CO2 equivalent emissions from this sector, 21% of the emissions were from rice cultivation. Crop soils emitted 13% of the total CO2 equivalent emission from agriculture. Rest 2.7% of the emissions is attributed to livestock manure management and burning of crop residue. The agriculture, forestry and allied sector contributes % to Assam's GSDP and is critical to the economy of the state. The contribution of animal husbandry to the GSDP is about %. Most of the rural and tribal communities keep livestock in their household that supplements their income and nutritional requirements. The GHG emissions from the agriculture sector are emitted mainly in the form of CH_4. These are due to enteric fermentation and from rice paddy cultivation. N_2O is also emitted from this sector and is mainly from the agricultural fields due to application of fertilizers. Livestock is a major anthropogenic source of methane emission from agriculture. Assam possesses around 3% of India's livestock population with a high degree of diversity in its composition. The total methane emission from Indian livestock was 11.75 Tg in 2003 of which enteric fermentation accounts for 10.65 Tg (~91%) compared to 1.09 Tg (~9%) by manure management. Assam contributed 2.7% of India's total livestock emissions (Chabra et al, 2009). India emitted 3.3 million tons of CH4 in 2007 from 4 3.63 million hectare of rice cultivation. In Assam 107758 hectare of total area which is 1.03% of the total area under cultivation. There are no state wise estimates of emissions from rice cultivation as emissions are function of the crop duration, water regimes and organic soil amendments. However, rice cultivation in Assam is only approximately 1 % of the total area under cultivation. One of the factors responsible for emissions from agricultural soils is the human induced net N addition in the soil caused due to synthetic or organic fertilizers, deposited manure, crop residues and sewage sludge. Since, agriculture in Assam is likely to face challenges due to

increased production demand, use of fertilizers will increase. Apart from this other sources includes field burning of agriculture crop residue which is common in certain areas. However, there are no firm estimates of emissions from these sources.

2.3.3 Land use, land use change and Forestry

to be added

2.3.4 Waste

Assam has shown high decadal urban population growth rate in recent years resulting in tremendous pressures on land, natural resources and basic infrastructural facilities. As per the census 1990 and 2001, number of classified towns increased from 93 in 1991 to 125 in 2001. In Assam, the Municipal Solid Waste generation rate is as follows:

Number of Cities	Municipal Population	Municipal Solid Waste (t//day)	Per Capita Waste (kg/day)
4	878, 310	196	0.223

Source: Saxena S, Srivastava RK, Samaddar AB, 2010

The main greenhouse gases emitted from waste management is CH_4. It is produced and released into the atmosphere as a by-product of the anaerobic decomposition of solid waste, where-by methanogenic bacteria break down organic matter in the waste. Similarly, wastewater becomes a source of CH_4 when treated or disposed anaerobically. It can also be a source of nitrous oxide (N_2O) emissions as well due to protein content in domestically generated waste water. The greenhouse gases and their source categories include municipal solid waste disposal, domestic waste water disposal, and industrial waste water disposal. There are no estimates of emissions from this sector at the state level.

Chapter 3 Existing policy responses and gaps

The reform process initiated since 2003 seems to have contributed to the economic growth recovery of Assam during the 10th plan period. However, still 36.1 % of the State's population lives below the poverty line against all India average of 26.1%. Majority of the population, especially the people living in interior rural areas, areas inhabited by Scheduled Caste & Scheduled Tribe population, tea garden areas and far flung "char" (riverine) lack facilities of safe drinking water, sanitation, curative health care & connectivity. Existing gaps have been identified by the State Government and certain goals have emerged for an inclusive development pathway (Approach to 11th 5 year plan, Planning and development department, 2011). But the phenomenon of climate change provides another dimension to the existing challenges by introducing risks to the inherent resilience of socio-economic and natural systems. Policy making in such a context has to deal with uncertainty and critical gaps in knowledge.

Assam has a high reliance on agriculture that is likely to only increase given its growing population. It is home to 68% of the northeast region's population and has a growth rate of 53.3%, making it is one of the fastest growing states in India. It is also the most densely populated northeast state, with 340 people per square kilometer. A growing population will undoubtedly put a strain on the agricultural sector. Climate changes pose additional challenges as higher temperatures increase the need for irrigation and the risk of heat stress or crop failure. Moreover, additional precipitation increases the risk of crop flooding. The State government has many programs to increase the growth of the agricultural sector, but issues relating to adaptation to climate change have started to emerge. Under such a scenario, strong participation in National Agriculture Insurance Scheme, development of high yield seeds, expanding storage facilities, increasing irrigation potential and steps towards sustainable farming becomes important

Climate change will also negatively impact the water resources sector by increasing freshwater scarcity, which is already a problem for Assam in the summer. The predicted increase in average temperature and decrease in the number of rainy days due to climate change will further stress water resources. This problem is compounded by high levels of groundwater extraction, which can be expected to continue given Assam's growing population and reliance on agriculture. Assam's water resource policies are distributive rather than proactive and there is yet a dearth of programs promoting water harvesting and water conservation or storage.

The northeast region has the highest forest cover in India, which provides a number of adaptive advantages. Forests can reduce soil erosion and runoff, regulate flooding and temperature and mitigate climate change. However, Assam has the lowest forest cover in the region at 35.5% and reports indicate that it is decreasing.[8] This has serious implications for the disaster management sector. Every year, Assam suffers from devastating floods. These are likely to become more frequent due to increasing precipitation, more frequent storm events, deforestation and a growing population living along the banks of Brahmaputra. A reduction in forest cover may also amplify the effects of mean temperature rise, impacting agriculture, water resources and the composition of the remaining forestland. Apart from the

[8] Forest Survey of India. 2005. State of the Forest Report. Available from http://www.fsi.nic.in/sfr_2005.htm.

goal of afforestation, conversion of wastelands into forests and management of jhum cultivation should also be prioritized. A sustainable land use policy for the State with appropriate regulatory measures is a critical requirement for effective management of the natural resources of the State.

Projections of melting glaciers in the Himalayas and also increasing precipitation will lead to swelling the banks of the Brahmaputra. At present, the responses to flood hazard has been more or less structural interventions which in turn pose risk for the river regime. Hence, there has to be studies regarding the river systems for a better understanding of the risks along with promotion of integrated watershed development programs. Scaling up of hazard mapping, early warning measures and assessments of vulnerability should take priority for long term interventions.

Finally, studies indicate that the effects of climate change will be felt most strongly by the poor.[9] Poverty is yet a major challenge for Assam as the poverty rate is 36%, higher than the Indian national average of 27% and also one of the highest in the northeast. Apart from economic growth, availability and access to public health services has been a challenge. The Ministry of Development of North Eastern Region and the North Eastern Council suggest that the people living on the small islands in the Brahmaputra River are the most vulnerable to disease outbreaks. They are isolated from the rest of Assam, have no permanent health care facilities and are prone to frequent flooding.[10] As climate change continues, these islands will become increasingly vulnerable and hence public health facilities need to be extended to such areas effectively.

A comprehensive review of the existing legislations, Government programs and schemes, etc. has led to the identification of a number of a number of policy goals relevant to the climate change context that are already being addressed. In the design of the State Action Plan on Climate Change it is important to take into account the existing interventions in the relevant areas and link them appropriately with adaptation needs and mitigation opportunities the following table presents this information-

[9] Mendelsohn, R., A. Dinar and L. Williams. 2006. The Distributional Impact of Climate Change on Rich and Poor Countries. *Environment and Development Economics* 11: 159-178.

[10] Ministry of Development of North Eastern Region & North Eastern Council. 2008. North Eastern Region Vision 2020

Goals	Policy strategies	Issues identified for adaptation and /mitigation to climate change
Boosting Growth rate of Agriculture sector	Programme implemented by Assam State Agricultural Department, including the schemes in response to flood, storm & drought hazard to agriculture	Lowering of water table of the Brahmaputra basin; acidity, alkalinity, elemental toxicity, iron & arsenic toxicity etc. in ground water; dwindling ground water level; erratic flood & drought condition; emergence of new pests and pathogens; exploitation of new resistant varieties and pest controlling chemicals; exploitation of new resistant varieties and pest controlling chemicals; difficulty in converting C3 plants to C4 ones in order to reduce CO2
Flood and erosion	ADB funded project on Flood and Erosion Risk Management of Water Resources Department (WRD); schemes of WRD under state plan; schemes of WRD under ACA, FMP and EFC; schemes under NABARD funding Pilot projects of Assam State Disaster Management Agency under Assam Disaster Policy, 2010	Deforestation, increase of pressure on land due to ad-hoc settlements, conversion of land into agricultural systems and destruction of wetlands; improper drainage system in urban areas; lack of studies on impact of flood control infrastructures in the regime of the rivers
Conservation of biodiversity, afforestation and upgradation of research and development activities related to forests	National policies acts and rules; Centrally sponsored schemes and State plan schemes	Decrease in the dense forest cover; encroachment of forest area; forest fires; declination of native forest; degradation of forest land; loss of wild life due to natural hazards and anthropogenic pressures; management of jhum cultivation
Improvement of health infrastructure and family welfare	Programs for immunization; Integrated Vector Control Program; services for non-communicable diseases, Programs for family planning; Rural sanitation programs; schemes for ensuring safe drinking water; schemes targeted for Tea Garden workers	Lack of awareness; availability of safe drinking water; access to sanitation facilities in rural areas; absence of effective inter-sectoral convergence; sanitation facilities pose a great challenge especially in the Char areas; all districts of Assam are affected with iron; 4 districts with fluoride and 19 districts with arsenic; some districts of Upper Assam, Lower Assam and the Hill districts are declared as endemic

		areas for vectore borne diseases such as Malaria, Japanese Encephalities and Filaria; urban areas are endemic to Dengue and Chikungunya; anemia due to Hb E and Sickle Cell Anemia are also equally high amongst the indigenous Tribal and Tea Tribes respectively including the general population; fluorosis is particularly rampant in the Districts of Karbi-Anglong, Kamrup (R), Kamrup (M), Golaghat, Karimganj and Nagaon; limited research on potential Health Impacts of Climate change
Conservation of soil	Projects under North East Council; Centrally sponsored schemes; projects under IWMP and Haryali; schemes under RKYV	Land degradation due to high intensity of rainfall, recurring floods, etc; indiscriminate felling of trees; unscientific land use; incidents of flash floods due to loss of soil; Severe river bank and other erosion like splash erosion, real erosion, sheet erosion, gully erosion etc; aggradation of river; sand casting of areas
Development of Urban Areas	Jawaharlal Nehru Urban Renewal Mission; Assam Urban Infrastructure Project; increase of buses for public transport by Guwahati Development Authority ; pilot schemes related to waste mangement	Lack of sewage treatment infrastructure; lack of public awareness; lack of suitable land for solid waste disposal
Conservation of fisheries	Fishery Rules 1953; Fishery seed act 2005	Availability of fishes in the affected areas is decreased during floods; loss of large water bodies specially beels been encountered; sporadic occurrence of epi-zootic ulcerative syndrome during flood and drought conditions; during floods risk of water borne diseases among fishes increase; stress on fishes due to depletion of water, lack of oxygen and outbreak of diseases during droughts; due to sudden change of the river courses especially in the Northern belt of Assam heavy deposit of silt in the natural and the culture fisheries occur during heavy flood events; no scientific validation of indigenous

		coping mechanisms and no studies on risks to fisheries
Achievement of energy security	Thrust on development of hydel power projects and there has been identification of sources for 2MW to 20 MW; pilot projects for solar street lights;	Most of the energy needs are met from thermal power stations which mainly run on fossil fuels like coal, oil, gas etc

PART B STRATEGIC APPROACH FOR ASSAM'S SAPCC

Chapter 4 Vision of the SAPCC

4.1 National Action Plan on Climate Change

Climate change is a global challenge with diverse implications at the national and sub-national levels, through impacts on various sectors such as agriculture, water resources, forestry & biodiversity, human health, energy and infrastructure. Such diverse impacts require a range of strategies to be deployed for an effective response and for better preparedness. These response strategies can be broadly classified as *Adaptation,* that is adjusting to the current and likely long-term risks and impacts of climate change and tapping potential opportunities that may arise; and *Mitigation*, that is reducing Greenhouse Gas (GHG) emissions from different sources or by increasing sequestration through sinks.

In 2008, a National Action Plan on Climate Change (NAPCC) for India was released by the Prime Minister. In view of the criticality of addressing the challenges posed by climate change along with the imperatives of poverty alleviation and economic growth for India, the NAPCC 'identifies measures that promote development objectives while also yielding co-benefits for addressing climate change effectively'. The focus of NAPCC is to improve the understanding of climate science, adaptation, mitigation, energy efficiency and natural resource management & conservation. The NAPCC, further, sets eight priority missions to respond to climate change; these include National Missions on Solar Energy, Enhanced Energy Efficiency, Sustainable Habitats, Water, Sustaining the Himalayan Ecosystem, Greening India, Sustainable Agriculture and Strategic Knowledge for Climate Change, covering a range of actions including adaptation and mitigation. The NAPCC outlines the following principles in this regard:

- Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.
- Achieving national growth objectives through a qualitative change in direction that enhances ecological sustainability, leading to further mitigation of greenhouse gas emissions.
- Devising efficient and cost-effective strategies for end-use Demand Side Management.
- Deploying appropriate technologies for both adaptation and mitigation of greenhouse gases emissions extensively as well as at an accelerated pace.
- Engineering new and innovative forms of market, regulatory and voluntary mechanisms to promote sustainable development.
- Effecting implementation of programmes through unique linkages, including with civil society and local government institutions and through public-¬private-partnership.
- Welcoming international cooperation for research, development, sharing and transfer of technologies enabled by additional funding and a global IPR regime that facilitates technology transfer to developing countries under the UNFCCC.

4.2 International Dimension (to be developed)

4.3 Vision of the Assam SAPCC

"*The Assam SAPCC envisages a sustainable and climate resilient development pathway through a synergistic combination of adaptation & mitigation measures with focus on research, appropriate technology, capacity creation and governance.*"

Chapter 5 Approach to the Assam SAPCC and criteria for prioritization

5.1 From Vision to Approach

There is a need to achieve synergy between national priorities and state-specific strategies, given that in many cases the actions being discussed are State subjects and have to be implemented in the States. While adaptation by its very nature is localized in action, mitigation actions taken at the state level can tap on the opportunities that the State can benefit from or follow a co-benefits approach simultaneously buttressing national mitigation efforts. In this context, it becomes crucial to prepare State Level Action Plans on Climate Change in order to address current and future climate risks and tap on potential opportunities through a diverse set of adaptation and mitigation strategies. The first step towards preparation of a detailed State Action Plan on Climate Change (SAPCC) is to identify state-specific risks & impacts and opportunities in the context of climate change. Thereafter, prioritize areas for research & policy action in response to identified current & future vulnerabilities and projected impacts of climate change. Effective policy design could be laid by juxtaposing identified strategies with national priorities and Missions.

While the NAPCC provides a roadmap that can guide states to prioritize a set of strategies for the state, the Ministry of Environment and Forests (MoEF), has also developed a common framework that can facilitate the States to prepare their State Action Plans in line with the broad objectives of the NAPCC, and it includes the following steps:

- Conduct ***scientific assessment*** of climate observations and projection, sectoral impacts and vulnerabilities, and prepare an inventory of greenhouse emissions in the state in order to identify vulnerable regions, sectors and communities for targeted adaptation and mitigation action.
- Identify Adaptation/Mitigation options based on the Missions identified under the NAPCC, consideration of ongoing programmes and projects in the state, and identification of additional strategies that may not be covered directly under the eight national Missions.
- ***Prioritize Adaptation/Mitigation options*** by taking into account the national policies, sectoral strategies under the national Missions and state level priorities, through multi-stakeholder consultations and interactions.
- Identify financial *needs* and sources to implement selected Adaptation/Mitigation options (MoEF 2010).

Table 5.1 presents the guiding principles for preparation of the SAPCCs.

Table 5.1: Guiding principles for preparation of the SAPCC (MoEF 2010)
• Implementing inclusive and sustainable development strategy that protects the poor and vulnerable sections of society from adverse effects of climate change
• Undertaking actions that deliver benefits for growth and development while mitigating climate change
• Ensuring and improving ecological sustainability
• Building climate scenarios and investing in knowledge and research to reduce uncertainty and improve knowledge about appropriate responses
• Assessing impact of climate change on existing vulnerabilities, and Identifying and enhancing risk management tools for addressing climate change
• Setting out options and evaluating and ranking them according to criteria (cost-effectiveness, cost-benefit, feasibility, ease of implementation, "no-regrets", robust to different scenarios, incremental vs transformative change etc)
• Identifying and implementing state-planned and community-based voluntary/autonomous adaptation
• Building broader stakeholder engagement to maximize perspectives and involvement in implementation
• Addressing state-specific priority issues, whilst also creating appropriate enabling environment for implementation of NAPCC at state level
• Considering governance and institutional contexts and ensuring appropriate Institutional arrangements and building capacities, keeping in view the coordination, inter-departmental consultations, stakeholder involvement, and integration with regular planning and budgetary processes
• Estimating additional resource requirements and exploring existing and new & additional carbon finance potential
• Linking up with national policies and programmes for consistency and to identify financial or policy support that may be available

However, it is important to understand that the nature of risks that will emerge in the future is uncertain and the scale of impacts may vary from that being witnessed currently. The state-of-the-art scientific knowledge and in-depth impacts & vulnerability assessment and emission profiling faces a number of challenges in terms of expertise, institutional capacities and resource availability to conduct these exercises. Hence, the SAPCC needs to be a dynamic document that should follow a regular interactive and iterative process to reflect new knowledge and developments at the national, state and local levels. For the realization of these actions at the State level, it is imperative for identified actions to be coherent with national priorities and State's own development plans. Therefore, SAPCC should build on the existing policies of the State by taking into consideration the ongoing programmes and schemes being implemented at the state level.

5.2 Thrust Areas and the Strategic Framework

The two basic premises underlying the Assam SAPCC are:

- National Priorities highlighted in NAPCC; and
- State-specific climate -related risks and opportunities

The Assam SAPCC is largely based on the available scientific literature and expert advice on the various response measures from representatives of various government departments and agencies. The approach to the SAPCC has been developed in view of observed trends and future projections of climate variability and change while simultaneously considering current and future trajectories of socio-economic development in the State. These climatic and non-climatic drivers define the current and future impacts and vulnerability profile of the State, and accordingly have helped in identifying the following six 'Thrust Areas' for the Action Plan.

1. Sustainable Livelihood: Major concerns are sustainability of critical ecosystems including agro-ecosystems, the creation of value chains at the local level, and risk management. Livelihood systems are considered for both farm sector (agriculture, fishery, livestock) and natural resource systems (forest, wetland).

2. Mitigating natural disaster and crisis management: Major concerns will be on preparedness, mitigation and vulnerability reduction in all forms of climate induced natural disaster.

3. Health: Major concerns relate to diseases that are sensitive to changes in climatic parameters, the access to health services of communities living in high risk areas; and the resilience of public health infrastructure.

4. Urban Planning: Major concern will be human settlement (includes housing, sanitation, drinking water, transportation, health and other amenities both in rural and urban context).

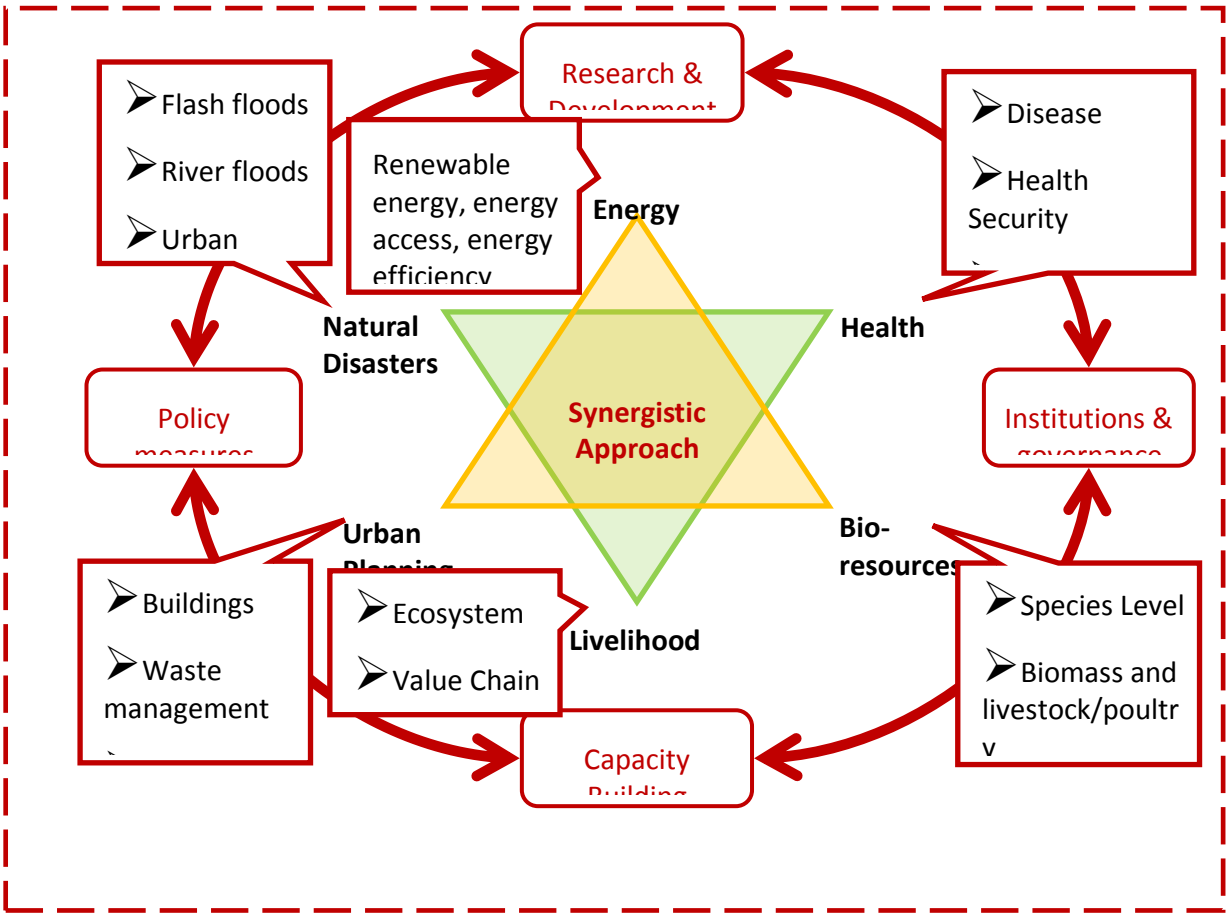
5. Energy (focuses on Energy sufficiency and efficiency): Major concerns will be technological initiations and intervention with more focus on harnessing new and renewable energy, energy efficiency and conservation.

6. Bio resources Protection and sustainable management of Forest and Wild Life: Major concern will be on forest and wild-life protection and developing resilience of eco-system services (includes RF, VF, PA and CCA and wetland under forest areas too).

5.3 Criteria for prioritisation

- No-regrets strategies and emphasis on co-benefits
- Principle of community based adaptation considered across sectors..
- People's participation

Figure 5.1 suggests the broad methodological approach that was undertaken for the development of the RAPCC.



PART C THRUST AREAS

Chapter 6: Sustainable Livelihoods

6.1 The farm sector: agriculture, livestock, and fisheries

6.1.1 Agriculture

Agriculture plays a vital role in the economy of Assam with 28, 75, 896 hectares of land under agricultural use, which represents 36.66% of the geographical area of the state (*Statistical Handbook, Assam, 2008, GoA*). The gross cropped area occupies about 36.37 lakh hectares. The cropping intensity is 152.43 percent. Rice, which is at present grown mainly during the kharif season, dominates the agriculture scenario in Assam, of which winter (Sali) rice in 2002-03 occupies an area of 17.49 lakh hectares and autumn (Ahu) rice another 4.64 lakh hectares. The third rice known as summer (Rabi) rice is grown in an area of 3.27 lakh hectares. The area under summer rice has shown an increasing trend with advancement of irrigation facilities mainly by way of Shallow Tube Well (STW). The other food grain crops like wheat (0.70 lakh hectares), pulses (1.23 lakh hectares) and maize etc. (0.20 lakh hectares) are also grown. The important commercial crops are oilseeds (3.39 lakh hectares), sugarcane (0.25 lakh hectares) and jute (0.68 lakh hectares).

Various problems like low seed and varietal replacement rates, deteriorating soil health and ground water, high humidity and low shelf life etc. are some of the very critical problems for the agriculture sector in Assam. The sector's overall growth rate since 1980s has been a little over 2 percent, which is not sufficient to generate surpluses for investment, or create purchasing power in the rural sector to provide a market for local industries. Cropping intensities and crop productivities remain low, and crop diversification is, at best, nascent. Fragmentation of land holdings, low irrigation coverage and the limited adoption of new technologies and practices are some of the constraining factors which are detrimental to the advancement of the sector.

In case of paddy, it has been observed that the yield rate of winter rice was low during the years 2006-07 and 2007-08 over the previous two years mainly due to drought like situation and severe floods that the state had experienced during the peak Sali Paddy season of the aforesaid years respectively.

With floods and droughts becoming a regular phenomenon, farm practices have been observed to be changing. Some examples are as follows:

- Summer paddy (irrigated paddy) became popular in the state in order to escape the crop damage due to recurring floods during Kharif paddy season. There have been fluctuations in kharif and summer paddy areas anticipating the occurrence of flood
- Summer paddy (irrigated) area has been increased due to coverage by this crop in previously fallow land of low lying areas
- Winter vegetable areas have been increased as measures of assured means of crop production

The challenges that Assam's agricultural sector is going to face in the coming days may be anticipated as follows:

1. **Threat to the sources of the Brahmaputra water:** Receding glaciers in the Himalayas at current rates may lead to the lowering of water table of the Brahmaputra basin. According to an estimate, irrigated agricultural area could reduce by 37 % in the country and the state would have to share a part of this constraint. Thus the normal soil moisture stress would demand more and more of assured means of irrigation from the remaining thin level of ground water
2. **Soil and Human health hazards:** Exploitation of ground water continuously at higher degrees would lead to soil health problems like acidity, alkalinity, elemental toxicity, etc. Iron and Arsenic toxicities have already been reported in the state. This would ultimately constrain the ground water exploitation. Therefore, use of surface water and solar electrical pump operated drip / sprinkler irrigation of harvested rain water would remain as the last resort of assured irrigation.
3. **Dwindling ground water level: C**ontinuous exploitation of ground water would ultimately result in problems of lesser availability and fluctuation in the level of ground water . This is already evident in urban areas due to installation of deep tube wells. For the rural agricultural sector, a strategy has to be evolved for changes in crops like adoption of dry land crops, reducing areas under rice crops which is the biggest source of methane gas, switching over to more C4 plants to increase carbon fixation as well as higher biomass production, adoption of very short duration crops to escape flood/drought, special package of practices for C3 plants like **System of Rice intensification(SRI**) and varietal selections, sowing time (due to phonological changes), crop rotations, type of tillage operations (Minimal tillage, zero tillage, use of rotovators, etc.) water harvesting (Watershed management, conservation of traditional water bodies, Boundary cropping in smaller field plots etc.). Moreover, to reduce the wastage of irrigation water, a policy of water pricing has to be evolved on PPP mode of operation.
4. **Erratic flood & drought condition:** The state would have to tackle untimely flood and drought conditions. Such incidents have been reported since 2003 in Assam. Not only do floods wreak annual havoc, but the accompanying uncertainty prevents farmers from taking risks and making investments in land improvement.
5. **Emergence of new pests and pathogens:** Changes in the agricultural sector brought about due to climatic change would normally shift the host pattern and life cycles of various insects, pests and pathogens. Many non-pest insects of cultivars might turn to be normal pests while many existing ones might perish forever. These would lead to exploring of new resistant varieties and pest controlling chemicals.
6. **Agriculture research:** There are demands to breed crops tolerant to higher extent of flood, drought, weed, pests etc. in the changing environment. In the climate change context, there is the challenge of converting C3 crops to C4 ones in order to reduce the atmospheric CO2.

7. **Agro-based industry:** The changing scenario of agriculture would have adverse impact on agro based industries
8. **Awareness:** The most difficult part of adapting to climate changes would be to change the mindset of the growers. It would take a great deal of continuous and tireless effort to make change the age-old practices of crop production before many of them quit the practice of agriculture and shift the mode of livelihood

Some of Assam's agricultural policies have the potential to mitigate the burden of climate change on farmers. There are district/state specific plans (based on various agro climatic conditions) for prioritizing the optimum and efficient use of available resources for better production and productivity. The Assam Irrigation Board works with the central government to fund and organize multiple small and large-scale irrigation projects. The state also engages in the recently introduced Participatory Irrigation Management (PIM) project, in which local farmers share responsibility for irrigation projects. Assam participates in the National Agriculture Insurance Scheme, which is sponsored by the central government. Assam's credit assistance scheme, jointly sponsored with the national government, provides coverage for losses to certain crops due to climate-related hazards such as storms, floods, landslides, drought and pests. In agricultural marketing, there are various schemes under Technology Mission for Development of Horticulture in NE Region, Rashtriya Krishi Vikas Yojana, Jute Technology Mission,etc. National Food Security Mission (NFSM) is all about increasing the production of rice through area expansion & productivity enhancement. Formation of Growers' Society & provision for distribution of Auto Van & transport subsidy to facilitate marketing to the distant market for assured remunerative prices.

6.1.2 Fisheries

The state of Assam has about 3 lakh hectares of water bodies in the form of rivers, ox bow lakes, swamps and ponds. These are important natural resources for production of fish in addition to other use of water in day to day life, agriculture, industry etc. There are 216 no.s of identified fresh water fish species most of which are economically important as table fish and some species have become endangered and are at different stages of vulnerability and their population has been drastically reduced. It may be mentioned here that fishery is an interlinked sector with health, industry etc. in addition to agriculture and allied sectors.

In Assam, most of the families have a back yard pond and around 95% of the populations are fish eaters. Around 5 lakhs of people are involved in fishery activities in the state. There is a positive trend of 6 to 8% annual growth rate in fish production in the state. Fishery contributes 2.6% to the GSDP of the state (2006-07) and there is tremendous scope to increase self employment opportunities among the unemployed as there is no dearth of marketing of local fish with good price in the state. Average annual income of fishery dependent families ranges from Rs. 10,000/- to Rs. 5,00,000/- depending on the size of fishery and method of farming. The fish produced in Assam also goes to neighboring states, though some fish comes from Andhra Pradesh and other states to Assam.

An overview of the fishery resources of Assam

Riverine fisheries	2,05,000 Ha
Beels	1,00,000 Ha
Derelict water/ Low lying area	39,000 Ha
Ponds and tanks	39,500 Ha
Production details (Season wise)	Not available

Major fisheries in Assam are the beels and rivers and in terms of production, beel fisheries production is the highest. The major fisheries are located in districts of Dhubri, Bongaigaon, Goalpara, Barpeta, Nalbari, Lakhimpur, Cachar, Karimganj and Nagaon.

Major fish species in Assam are Catla catla, Labeo rohita, Labeo gonius, Cirrhinus mrigala, Mystus seenghala, Anabus testudineus, Channa striatus, Clarias batrachus, Heteropneustes fossils, Notopterus chitala. There are some endangered species like Ompok pavda, Puntius sarana etc. and to increase their population captive breeding and conservation measures along with awareness programme among the fishermen has been taken up. Presently composite fish culture technology in ponds, tanks, cage and pen culture is adopted in the beel fisheries to increase fish production. Innovative technologies for production of Monopterus, Cuchia, Notopterus chitala, Mystus senghala and Clarias batrachus has also been introduced to augment fish production. Major fish disease occurred in Assam is, Epi-zootic ulcerative syndrome during winter season. The disease is almost controlled except sporadic occurrences in certain places at present.

Challenges and key issues: According to the Fisheries Department, there is a destruction of natural habitat and exploitation of fishery resources in the state. Disasters like flood and river erosion greatly affect the availability and productivity of fishery in Assam.

a. During flood events, the availability of fishes in the affected areas is decreased to a certain extent. The affected districts are Lakhimpur, Dhemaji, Sonitpur, Dibrugarh, Tinsukia, Sibsagar, Jorhat, Golaghat, Morigaon, Kamrup, Nalbari, Barpeta and Dhubri. Fish culture is also severely affected in the flood prone areas in Assam.

b. River erosion is a serious threat to the fisheries of Assam, with the loss of large water bodies specially beels been encountered already. The fisheries in the heavily flood prone areas are facing this threat of river erosion.

c. During flood and drought like situation, stresses and sudden disturbances occurs due to sporadic occurrence of Epi-zootic ulcerative syndrome.

d. Fishes in Assam are also subjected to numerous water borne diseases. In the flood prone areas the fishes generally try to escape the pond and are afflicted with numerous water borne diseases.

e. During droughts the fishes undergo severe stress due to depletion of water, lack of oxygen and prevalence of diseases.

f. The current knowledge is based on traditional methods to tackle this problem. No study has been conducted regarding future risks.

g. The major fish disease like the Epi-zootic ulcerative syndrome occurs during the winter season. At present, the occurrence of the disease is almost controlled except for sporadic occurrences in certain places

h. In the fisheries sector new risks emerge as there have been recorded unprecedented drought like situation in some districts during the year 2007-2008 and 2008-2009 respectively. Moreover, due to sudden change of the river courses especially in the Northern belt of Assam heavy deposit of silt in the natural and the culture able fisheries occur during heavy flood events.

The Government of Assam has enacted Fishery Rules 1953 and Fish Seed Act 2005 for conservation of Fishery resources in the state. In view of state policy on climate change, fishery sector can contribute towards adaptation and mitigation of coming eventualities involving more and more people in the sector for research, self employment, community participation and up-gradation of socio economic status as well as human resource development. In order to cope with the changed environment, there may be drastic change in the fish distribution, production in culture fisheries. So, technical manpower of the department and technical know-how of the fish farmers and other stakeholders must be in accordance with the scenario. A detailed study and research is the need of hour.

6.1.3 Livestock (to be developed)

6.2 Assam's biodiversity and forest wealth

Assam's forest wealth is facing a number of severe threats and pressures. The forest cover in the state is 27,692 sq. km, which is 35.3 % of the State's geographical area and consists of 1,461 sq. km of very dense forest, 11, 558 sq. km of moderately dense forest and 14, 673 sq. km of open forest (FSI, 2009). There has been a loss of 66 sq. km of forest cover since the last FSI assessment including a decrease of 3 sq. km in very dense forest, 95 sq. km in moderately dense forest and an increase of 32 sq. km in open forest. The loss of forest cover is due to encroachment in the districts of Sonitpur, Karbi Anglong and Darrang as well as some decrease in forest cover due to shifting cultivation in North Cachar hills, Karbi Anglong and Kokrajhar (FSI, 2009). Loss of lowland forests of Assam, which are particularly rich in biodiversity due to encroachment and logging are important factors in the increased vulnerability of the fragile forest ecosystems of this state to climate change. Vast areas of forest have been eroded and lost to biotic pressures, and encroachment of forest areas is the primary reason, particularly in response to recurring floods in the Brahmaptura and its tributaries and more recently armed militancy (ASTEC, 2004). Poaching and unsustainable extraction threaten the long-term integrity of forests in this ecologically fragile region. Extraction of crude oil and coal is also another pressure on the forests.

Another important factor in deforestation is the practice of jhum (shifting cultivation) and the reduced rotational cycles that are practiced today. Nevertheless, the traditional practice of jhum uses at least 35 varieties of crops underscoring its role in promoting the use of several traditional varieties of crops (Chatterjee, 2006). Important issues that need to be addressed for Assam, particularly in the context of deforestation and climate change include the reduction of deforestation and degradation particularly encroachment and associated concerns of logging, habitat fragmentation. This must be accompanied by efforts to reduce the vulnerability of forest dependent communities to climate change by developing the NTFP potential of the state including medicinal plants, bamboo and cane as well as devising ways of addressing the pervasive issue of jhum cultivation. The enormous, and to a great extent still unchartered biodiversity of the State, needs to be inventoried and traditional practices documented through biodiversity registers. These efforts can feed into biodiversity based community ecotourism that will bring in much needed revenues for local communities and ensure the sustainable management of forests, wetlands and biodiversity.

Forest ecosystems in particular are among the natural systems that will globally be severely affected by climate change (Pérez-García et al., 2002; Walther et al., 2002). This is also true for the forests of Assam and its adjoining North Eastern States. Climate change is likely to have multiple effects at the individual, the species as well as the ecosystem level due to increase in atmospheric carbon dioxide and resultant temperature increases and changes in rainfall regimes. At the ecosystem level, this may result in increases in biomass production, alteration in forest structure and species composition and competitiveness, and an increase in soil mineralization changes (Meer et al. 2001). At the community level, changes in floral and faunal phenology will likely adversely impact critical process of pollination and seed dispersal.

Traditional hunting by tribes and indigenous communities is a common practice in the whole of the North East including Assam that has caused declines in populations of large-bodied vertebrates. Recent studies indicate that hunting of frugivores which play a critical role in seed dispersal and forest regeneration, in particular, can greatly alter the structure and composition of forests. Hunters preferentially target large-bodied animals which are particularly susceptible to declines given their slower population growth rates and extensive home-ranges. Increasing evidence from South America and Africa that defaunation causes forest-wide alterations in species composition as large-seeded trees are increasingly replaced by smaller-seeded species (Nunez-Iturri and Howe, 2008; Vanthomme et al. 2010). Some studies indicate that this may be happening in Assam and Arunachal as well (e.g. Sethi and Howe, 2009). This has important implications for climate change as there is evidence of a positive relationship between seed size and tree wood density. Reduced abundance of large-bodied animals that disperse the large seeds of trees with high wood densities could disrupt the reproduction of these tree species. This in turn could reduce the carbon sink provided by tropical forests (Brodie and Gibbs, 2010).

The effects of climate change on a rich but fragile ecosystem that is already under multiple threats from habitat fragmentation and loss, hunting, logging, mining, shifting cultivation, suggests a decrease the resilience of forest biodiversity to adapt to these changes. This will in

turn enhance the vulnerability of forest dependent communities to climate change and possibly reduce their ability to adapt to ecosystem wide changes. Forests and biodiversity play an integral role both in the mitigation as well as in the adaptation to climate change. Biodiverse forest and wetland ecosystems provide multiple goods and services such as climate regulation, carbon sequestration, pollination, seed dispersal, flood control and recreation values (Daily et al. 1997). Importantly, forests, water and biodiversity also form the bedrock of the livelihoods of millions of rural communities in the developing world, but land use change, biodiversity loss and climate change threatens their very existence, and the ecological, cultural, livelihood and food security of natural-resource dependent communities. It is estimated that deforestation and degradation contributes around 20% of total GHG emissions. Reducing deforestation and degradation is thus a key strategy for addressing the issue of climate change as well as a means of ensuring the sustained production of forest goods and services for meeting the livelihood needs of forest dependent communities as well as for society at large.

Climate change is likely to have an immediate and devastating impact on the poorest communities. Forests provide germplasm, traditional resources and knowledge as well as basic livelihood needs such as fuelwood, bamboo, fodder, timber and Non Timber Forest Products. Biodiversity dependent communities with little access to health facilities utilize local traditional knowledge and medicinal plants. If climate change impacts forest ecosystems thereby decreasing water regulation and forest ecosystem services including the provision of important forest products, this in turn may result in increased social vulnerability. This is likely to be exacerbated by increasing population growth. Consequently, reducing deforestation and ensuring a continued supply of these forest products is essential as a means of helping local communities to build their resilience and facilitate adaptation to climate impacts.

Adapting to climate change will require that traditional knowledge is also protected and promoted given that local communities have often followed traditional practices to reduce the impact of natural disasters such as flooding. For example, regular flooding in the river Brahmaputra of the Eastern Himalayas is a common occurrence during the rainy season, often impacting the town of Dibrugarh in Assam, but was earlier not perceived to be detrimental (Das, 2003). Traditional wisdom was used to predict the occurrence of these floods-e.g. the movement of ants or the behaviour of the *gagini* locust (Das, 2003). Local plantain and bamboo rafts called bhoor were rapidly built to escape the floodwaters while loose bamboo matting was used to form a barrier to trap fish in the flood waters (Das, 2003). Adaptation to climate change must therefore also foster research that explicitly incorporates aspects of biocultural diversity within socio-ecological practices as a means of adaptation to climate change.

In the light of climate change, several issues and challenges need to be prioritized. Some of these are listed below.

- Preventing the encroachment of forest areas and consolidating and demarcating reserve forest boundaries

- Working with local communities for the sustainable management of forests. In particular, the forests managed by Autonomous Councils namely the North Cachar Hills Autonomous Council, the Karbi Anglong Autonomous Council and the Bodoland Territorial Council are located in ecologically fragile and hydrologically important areas located upstream of the flood prone Brahmaputra and Barak valleys. Consequently, there is an urgent need to enhance the capacity of these autonomous councils to manage the forests of these regions as contiguous forest units and to work with communities to develop REDD plus (Reduced Emissions from Deforestation and Degradation) initiatives
- Developing the Non Timber Forest Product (NTFP) potential of the State particularly medicinal plants as well as the bamboo and cane sector so as to create sustainable livelihoods for forest-dependent communities
- Addressing the issue of shifting cultivation by providing alternative income generating opportunities including biodiversity-based tourism and rehabilitating forest areas under jhum cultivation
- Reducing hunting of wildlife by tribal populations especially since defaunation of tropical forests may lead to alterations in forest structure and composition that may indirectly impact the carbon sequestration capacity of forests (Brodie and Gibbs 2010)
- Man-animal conflicts are an issue of grave concern for Assam, particularly elephant-human conflicts (Barua and Guha, 2008) [11]. About 5000 elephants, 20% of the country's total are found in Assam (Zimmerman et al., 2009) [12], but given encroachment and the high reliance of local communities on forest products this has resulted in escalating conflicts (Kushwaha and Hazarika, 2004).

[11] Barua, R. D. and Guha, I. , 2008-07-10 "The case study of national parks and sanctuaries and man-animal conflict due to land constraint in the Brahmaputra valley " Paper presented at the annual meeting of the International Congress for Conservation Biology, Convention Center, Chattanooga, TN <Not Available>. 2011-03-11 from http://www.allacademic.com/meta/p240999_index.html

[12] Zimmermann, A., Davies, T. E., Hazarika, N., Wilson, S., Chakrabarty, J., Hazarika, B. and Das, D. 2009. Community-based elephant conflict management in Assam. Gajah 30: 34-40.

	THRUST AREA 1: SUSTAINIBILE LIVELIHOOD (Sub-section1 Farm sector: Agriculture, livestock and fishery)
	Strategies
Research and technology development	Impacts assessment (crops, livestock and fish species) Studies on weather pest relationships
	Developing data base on genotypes of local crop varieties (mainly rice varieties) and identification of suitable varieties for different agro-climatic zones in the context of climate change impacts. Special emphasis on developing genotypes for tolerance to biotic/abiotic stress, e.g. drought, flood, disease and pest resistance
	Developing Decision Support System combining database (of crop, soil, weather) and modern information tools (with simulation models, remotely sensed information, use of GIS platforms) to provide drought/flood alerts, monitoring the vegetation condition, develop crop yield forecasts and, identify best agronomic practices
	Proper research on making agriculture possible on soil degraded due to sand deposition as well as on restoration of such soil to reclaim productivity
	Documentation of indigenous technical knowledge and its standardisation in the context of climate change adaptation
	Restructuring or re-designing of crop calendar and cropping systems /patterns and crop adaptability. Define land use suitability classes at water shed/micro-watershed level for the entire state and renewal of the classification every five years to deal with changes occurring to agricultural land due to natural and anthropogenic factors.
	Identification and documentation of traditional practices for fisheries
	Research for standardization of local air breathing fishes; and new candidate species to be taken care
Policy measures	Review and reframing of State Agriculture Policy in the context of climate change vulnerability, incorporating the strategic guideline for each of the agro climatic zones by a) establishing linkage of agricultural policy with those on water and land use so that they become synergistic and complementary to one another, especially with respect to irrigation and other means of water harvesting for agricultural uses and b) introduce and promote insurance of crop, farm land and livestock by ensuring minimum risk for farmers.
	Fiscal support for soil conservation strategies in cultivable wasteland of the state (land reclamation and water distribution): Restoration of soil degraded due to deposition of sand to recover its productivity along with incentives and subsidies to affected farmers.
	Fiscal incentives for promotion of agro-forestry in different agro-climatic zones, with special attention to the hill areas for improvisation of traditional agricultural practices like shifting cultivation (jhum), to reduce ill effects on environment and increase productivity.
	Strengthening the role of farm cooperatives
	ACZ wise crop planning based on strategic knowledge partnerships between government agencies and research organizations/ agri-universities

	Introduction of the concept of seed village to ensure the reliability of seed supply through proper procurement and distribution systems
	Budget support for upgradation of Departmental fish farms to bear possible effects of climate change
	Expansion of integrated fish farming, such as integrated Paddy cum fish, Pig cum fish, Duck cum fish
	Registration of fisheries and policy support for SHGs for scientific management of beels and river fisheries
Institutions and governance	Introduction of surveillance to monitor and combat fish disease from dist. H.Q
	Strengthening the role of farm cooperatives
	Strategic knowledge partnerships between government agencies and research organizations/ agri-universities
	Mechanism for interdepartmental collaboration and coordination
Capacity Building	Sensitize Kissan Bandhus and farmers in general regarding potential climate change impacts and the adaptation choices.
	Awareness and capacity building of extension staff on the issues of climate change risks and adaptation
	Pilot demonstration projects on information support systems in every agro-climatic zone of the state
	Training of Departmental Officials, Upgradation of Training Institutes in terms of infrastructure and scientific backup involving Universities, ICAR Institutes, and the Fishery College
	Awareness among fisherman and livestock owners
	Development of seed and fodder banks in flood prone areas at the panchayat level

THRUST AREA 1: SUSTAINIBILE LIVELIHOOD (Forestry, biodiversity and wetlands)

Strategies
Mapping of the bamboo and cane potential of the state including documenting the different varieties and their phytogeography. Also, Documenting the traditional uses of bamboo and cane in Assam including associated practices and traditions and reviving of bamboo/rattan handicrafts
Establish scientific and sustainable harvesting methods that prevent excessive harvesting and low regeneration of bamboo species
Establish gene banks and seed orchards and develop appropriate techniques for propogation and variety improvement including use of biotechnology for bamboo and cane species
Document the rich traditional knowledge of the State through People's Biodiversity Registers including those that are relevant for minimizing the impacts of climate change for human, animal or plant health, agricultural productivity or livestock development
Carry out biodiversity inventories and research pertaining to the conservation and sustainable management of forests, wetlands and protected areas
Identification of important research priorities and sites vis-à-vis climate change and natural ecosystems including standardization of methodologies and identification and prioritization of plant and animal taxa that can be used as bio-indicators (e.g. lichens) and also setting up of long term monitoring plots (e.g. like the 50 ha monitoring plot in Mudumulai) that can be used specifically for research purposes into the long term dynamics of forests/other ecosystems and their component communities
Carry out systematic and targeted research aimed at understanding the role of forests and natural ecosystems of the state in mitigating and promoting adaptation to climate change as well as the impacts of climate change on the physiology, ecology, phenology, reproduction, migration and biogeography of natural ecosystems and organisms.
Identify the medicinal plant wealth of the state including priority areas and species. Sacred groves for example often harbor a rich diversity of medicinal plants. Document the usage and traditional customs and practices for medicinal plants c) Assess the population status of medicinal plants that are thought to declining and/or endangered
Develop and provide good planting material that can be grown commercially by local communities.
Promote standardization and clinical trials for important medicinal plants to establish and validate their medicinal value.
Development of the bamboo and cane sector for Assam including effective implementation of the Bamboo and Cane Policy of Assam.
Ensure that bamboo forests on mountain slopes are protected so as to stabilize and protect mountain slopes and ensure the conservation of biodiversity associated with bamboo forests and rattan brakes
Develop a community-based wetland policy for the State that ensures participatory management of wetlands perhaps along the lines of JFM
For Assam, it is important to document the immense wetland biodiversity of the state and document the traditional practices associated with wetland conservation and management
The state forest policy 2004 should undergo a critical review in the light of climate change mitigation and adaptation measures

Frame a wetland policy that recognizes the rights of local communities to manage wetland resources in a sustainable and ecologically responsible way and also emphasizes on restoring important wetlands by using existing programmes and schemes such as the National Rural Employment Guarantee Scheme to ensure wetland creation and restoration, development and rejuvenation of traditional water harvesting systems
Promote biodiversity-based ecotourism by involving local communities
Create a State Wetland Authority to address issues pertaining to the conservation and management of wetlands and their aquatic flora and fauna as well as their sustainable utilization, eco-restoration and other economic uses
Budget support for alternative livelihood opportunities for people living in forest fringe areas
Comprehensive wildlife management plans for the state (including issues related to prevention of wildlife trade, protection of corridors, management of sanctuaries and national parks etc.)
Enhance the farm forestry capability of bamboos and rattans and facilitate their plantations by farmers and develop public private partnerships that ensure the bamboos and rattans are an attractive investment option. Further, foster their plantation on homesteads and as wind breaks to meet the needs of rural livelihoods
Involve designers and artists to ensure value addition of traditional handicrafts and develop effective market linkages for their promotion
Strengthen the capacity of local communities to manage forests, biodiversity and wetlands using participatory approaches that are locally acceptable and sensitive to local traditions and systems for the management of land and forests.
GIS based mapping as a strategic precaution to deal with forest encroachment (possibly, pilot projects in identified areas)
Public awareness of wetlands of strategic, cultural and biodiversity importance including those of historical value
Training of frontline staff of the forest department and other agencies related to environmental and natural resources management
Capacity building of NGO's
Introduction of green curriculums in schools and training of teachers
Development of communication material in ethnic languages like Bodo, Karbi etc.

	THRUST AREA 1: Sustainable Livelihood (Value chain, markets and risk management)
	Strategies
Research and technology development	Research for alternative fish feed and also technology development for conservation of live gene of local fish fauna value chain
	Research to enable designing of appropriate crop insurance schemes and also amalgamation of livestock insurance with the same
Policy measures	Promoting the use of ICTs such as information through internet or mobile phones
	Incentives to promote agro-based and forestry based processing industries.
	Strengthening Basic Infrastructure i.e. road, rail and transport
	Promotion of organic food, processed food
	Promoting investments in post harvest infrastructure such as cold storage, transport and other storage facilities such as godowns and processing units to reduce post harvest losses
	Expansion of local ornamental fish production for marketing and livelihood
	Policy on micro-credit lending and creation of facilities for small units and farmers
	Micro insurance and micro credit lending for SHGs involved in fisheries
	Policy measures to encourage banks and other financial agencies to fast track the penetration of insurance products
Institutions and governance	Setting up of a regulatory body to check misuse of insurance and credit lending schemes
	Empowering KVKs with information support systems and advisories on value chain management and risk hedging
	Monitoring role for Panchayats to ensure interventions are inclusive and implementation is effective
Capacity Building	Training to the local communities from the design experts to better the handicraft industry
	Awareness program for existing insurance programs
	Building market information, intelligence and forecasting system for farmers which will guide farmers related to the sowing time, harvesting time, best agriculture practices
	Sophisticated hatcheries to be incorporated to make available quality fish seed in advance and round the year
	Capacity building of communities for sustainable harvesting of NTFPs, value addition and marketing and developing value chains
	Creation of rain water harvesting structure for fish farming and other avenues

Chapter 7: Natural Disasters

7.1 Current status and recent trends

Some of the predicted impacts of climate change on the entire Himalayan region are rising temperatures, recession of glaciers, extreme rain events, increased incidences of landslides, cloudbursts, and flash floods which may pose a risk to hydrological regime of the large rivers of the region like the Brahmaputra River (Das, Chutiya & Hazarika, ICIMOD, 2009). At least in the short term, Assam faces the risk of excessive flooding of the Brahmaputra River due to predicted changes of the climatic system. The losses associated with flooding, erosion and sand deposition has already reached overwhelming heights and has proved to be detrimental on the livelihood and subsistence needs of the people. The Brahmaputra River is recognized as a resource as well as a source of vulnerability.

The geo-environmental setting of Assam makes it highly susceptible to multiple hazards caused by geological, climatic and hydrological factors. The north region of the state is a hotbed of the monsoons. As a result, the rivers of the region are hydrologically dynamic in tune with the monsoons and also the freeze and thawa cycle of the Himalayan and trans-Himalayan glaciers and snow cover. Assam being surrounded by hilly areas through which most of the major rivers enter the valleys the state regularly experiences very high rainfall in the summer season including extreme events like cloud bursts often leading to catastrophic hydrometeorological hazards mainly floods and flash floods. The river Brahmaputra has 20 major tributaries joining from its north and 13 from its south. The north bank tributaries are mostly unstable, carry excessive sediments and therefore mainly responsible for the heavy sediment load of the Brahmaputra river, siltation of the river bed and lateral shifting of the river resulting in acute erosion of river banks (ASTEC, 2011).

Since 1950 river bank erosion became a major threat for the state because of the affect of the major earthquake in the eastern part of the state. So far, around 7.5% land of the state has been eroded by the Brahmaputra River which amounts to an annual average of 8000 hectares of land erosion by rivers. Two hill districts and hilly belts of other districts including the hills of Guwahati city regularly experience landslides. Rainstorms and thunderstorm are two other hazards that the state suffers from, particularly during the pre-monsoon season. Occasional cyclones during monsoon season also cause severe damage to life and property. The severity of such cyclones is more in the western Assam. In the recent times, many parts of the state also witnessing drought like situation particularly in the dry winter and pre-monsoon seasons.

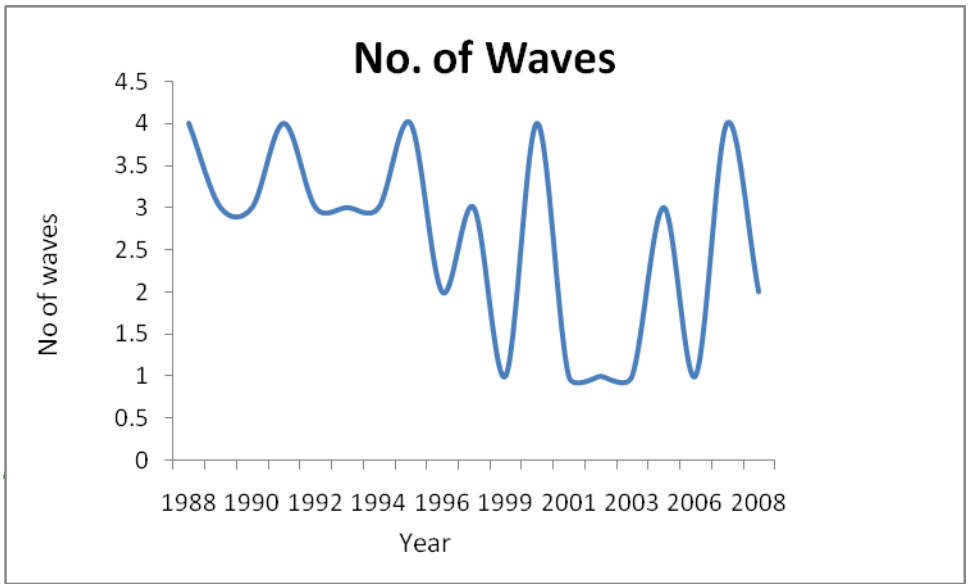
On the basis of consultations with the Water Resource Department and Revenue and Disaster Management Department of the Government of Assam along with the Assam Science Technology and Environment Council (ASTEC) and a literature review we delineate seven natural hazards which pose as risks for disasters in Assam.

7.1.1 Floods

The basin of the Brahmaputra River is among the most floods prone in the world (River Flooding and Erosion in Northeast India, 2006). The extremely dynamic monsoon regime along with the unique physiographic setting of the basin has been considered as the single most cause for frequent occurrences of floods in this region (Assam Staff College Report, 2005). The basin experiences highest number of floods in India during the monsoon rains and suffers flood damages on an annual basis (Kienberger & Johnson). Historical records reveal that the valley faced flood hazards since primeval times (Assam Staff College Report, 2005). The table below shows the flood damage trends in the Brahmaputra valley of Assam the period of the year 1953 to 2005 respectively.

Period	Average annual area flooded (Million Hectares)		Flooded crop as % of total inundated	Average annual damage (Million Rupees)	Value of crop lost as % of total damage
1953-1959	1.13	0.10	8.85	58.6	66
1960-1969	0.75	0.16	21.33	75.7	92
1970-1979	0.87	0.18	20.69	151.8	89
1980-1988	1.43	0.40	28.05	1455.2	96
1999-2005	1.07	0.38	35.65	7171.7	34

Source: Assam Water Resources Department Report, 2006



An analysis of above data suggest an average crop loss of Rs 6417 hectare/year

from annual average of 0.38 million hectare agricultural crop area affected by floods during the period from 1999-2005 which accounts for 14% of the net agricultural cropped area (Assam Water Resources Department, 2006). Floods affect an annual average of 0.8 million hectares of land, but in some year they affect more than 4 million hectares of Assam's total area of 7.54 million hectares. Such extensive floods inundate at least 2,000 villages in addition to destroying other infrastructure (River Flooding and Erosion in Northeast India, 2006). The numbers of flood events from 1998 to 2008 are shown by the graph below:

According to the Second National Communication to UNFCC, 2010, out of the total area of 3.58mha that are prone to flooding, 3.15mha fall within the state of Assam. The tenth five year plan indicates a crop loss of a value of Rs. 14559.95 lakhs. The flood damages to crops, cattle, houses and utilities between 1953 and 1995 is estimated at Rs, 44, 00 crore with a peak of 664 crore in a single year (Assam Staff College Report, 2005). The damages due to floods and erosion are enormous, affecting an average area of 9.31LHa in a year amounting to a loss of 124.28 crores (Water Resource Department, Government of Assam, 2006). Flooding is a major recurrent natural calamity; therefore the high flood risk discourages private investments in productive activities and is thus a key contributor to persistent regional and rural urban disparity (Asian Development Bank, 2010). The table below shows the loss of human lives, cattle, crops and the area affected since the 1998 to 2008.

Year	Area effected (M.Ha.)	Damage to Crops Area in (M.Ha)	Cattle Lost (No's)	Human Life Lost (No's)
1988	3.82	1.10	46210	232
1989	0.72	0.37	3086	34
1990	0.49	0.21	4787	28
1991	1.00	0	21627	108
1992	0.21	0	58	12
1993	1.25	0	13560	72
1994	0.05	0	95	7
1995	0.07	1	12860	53
1996	1.00	1	3000	37
1997	0.75	0	1961	28

1998	1.32	0.47	86224	125
1999	0.22	0.0590	992	3
2000	0.97	0.3220	19988	36
2001	0.2	0.0360	15	4
2002	1.19	0.2990	4294	65
2003	0.93	0.2950	4319	52
2004	2.85	1.25	50524	251
2005	0.22	9.84	50000	29
2006	0.05	0.0104	28	7
2007	1.5	0.67	0	134
2008	0.04	0.0134	8002	40

Source- Water Resource department, 2010

The annual cycles of flood hazards cripple people's resilience and intensify the poverty spiral (Das, Chutiya & Hazarika, ICIMOD, 2009). The Brahmaputra and its tributaries like, Buridehing, Manas, Pagladiya, Desang, Subansiri, Dikhow, Sankosh, Puthimari, Beki, Jai Bharali, Dhansiri, Kushiyara, Katakhal and Barak flow above the warning level. There are 21 districts namely Barpeta, Bongaigaon, Cachar, Chirang, Dhubri, Darrang, Dibrugarh, Dhemaji, Golaghat, Hailakandi, Jorhat, Karimganj, Kamrup, Kokrajhar, Karbi-Anglong, Lakhimpur, Morigaon, Nagaon, Nalbari, Sonitpur, Sivsagar that were affected by the floods in the year 2010. A total number of 74 talukas, 3, 630 villages and 25, 45, 560 population were affected. A total number of 17 human lives, 3, 754 cattle, 147, 037.69 hectors of land were damaged and lost in the same year. The following districts Barpeta, Bongaigaon, Chirang, Dhemaji, Darrang, Dhubri, Hailakandi, Jorhat, Karimganj, Lakhimpur, Morigaon, Nalbari, Nagaon (Kaliabor), Nagaon(Hojai), Nazira, Sivasagar and Sonitpur were affected in terms of infrastructure and essential services i.e. power supply, water supply, road transport, health sector and telecommunication etc (Daily report, Revenue and disaster management, 2010).

7.1.2 Flash floods:

Incidences of flash floods are new and increasing and pose as challenge to management due to its unpredictability (as informed by Jayanta Goaswami, Director Planning, Chief

Engineer's Office, Water Resource Department, Assam). The damage caused and some of its causes differ according to the landscape and development contexts of different districts.

Morigaon and Nagaon Districts: Source Water Resource Department, Assam

In the month of July 2004, due to incessant rainfall in the Kopili-Kolong basin, rivers like Kopili, Kollong, Nonoi and the Brahmaputra created havoc in the districts of Morigaon and Nagaon. The spill ways of the power projects in the upstream region namely Kopili H.E. Project (KHEP) of NEEPCO and Umiam H.E. Project of SEB Meghalaya, released abruptly and contributed to the catchment aggravating the situation and causing widespread devastation downstream

The excess release from Kapili Dam in Karbi-Anglong resulted in overtopping of the entire embankment system on both banks of Kopili River and caused devastation to the whole Nagaon district. The unpredictable flood caused by the river Kopili-Kollong & Nonoi damaged the Kopili-Kollong basin. Floods of such high magnitude causes the embankment system of Kopili, Kolong, Nonoi etc. to get severely breached mainly due to overtopping in as many as 181 locations out of which 78 nos falls under Morigaon E & D Division and 103 nos falls under the Nagaon E& D Division.

Barpeta and Nalbari Districts: (Source Water Resource Department, Assam, 2010)

Nalbari and Barpeta were the worst hit districts in the 2004 floods of Assam. The two districts suffered large scale devastation and losses. The river system of Nalbari & Barpeta districts comprises mainly of the following:

- Beki
- Manas
- Pagladia
- Mora-Pagladia
- Baralia
- Nadla drainage channel
- The Hakua
- Kaldiya
- Bhllengi
- Mora-Choulkhowa
- Noona
- Barnadi

Most of the rivers of Nalbari Dist have their origin in Bhutan. The burst of artificial dam of Kurichu Power project which is situated in Bhutan was the main reason of the devastation and havoc caused. After the construction of the dams of the power projects, there was ponding of water, which loosened the soil of the lofty hills falling within the lake area of the

power project, due to the loosening of the base of the lofty hills within the lake area on Tsatichlus river (a tributary of Wabragchus which joins Kurichhu) huge landslides occurred on the 10th of September 2003. These landslides created the possibility of breaking the dam and thus carried a signal of a severe disaster in the plains of Assam namely the, Manas-Beki-Hakua plains.

On the 10th of July 2004, it was reported that the Tsatchu Lake above Kurichhu had burst and the entire water of the lake was coming down. The river Kurichhu was flowing 3 meters above H.F.L. The water level of the river Gamri had gone quite high that way. This tremendous discharge of water associated with heavy rain ultimately merged into the river Manas; nearly 50% of the run off of the territorial area of Bhutan finds its way through a huge number of tributaries and sub-tributaries, which combine near the foot hills of Bhutan. This Bhutan Manas just after debouching name Manas, the middle course is known as Halena at U/S and Bhalukadoba at D/S and the Eastern most course of the trifurcation is known as river Beki.

The huge debris laddened with uncountable number of trees, logs, boulders and other debris found their way into these three courses in Assam, the courses of Manas and Hakua combined with this debris got choked totally. The discharges of Manas and Hakua joined the Beki flow, Beki was in such state that its banks were washed away along with the standing trees of the internationally important Manas National Park. This combined flow made headway up to 15/16 Km. The debris carried by this flow got accumulated in such a colossal manner that the course of Beki also started getting choked near Narayanguri just at the dorsal side of the border of the Manas National Park. The breach was at an inclination of 90^0-95^0 within the main course of Beki. A nearby, small rivulet (5/6 m wide) called Kalapani catered the field runoff of the area. Kalapani had no capacity to cater this huge discharge of these three rivers, therefore, the entire area comprising about 130 villages and adjoining spreads of cultivated land about 7-8 km in width and 40-45 km in length was submerged to roof height depth. The entire road communication links to these huge areas were breached and got submerged. National Highway 31 also got submerged and the R.C.C. Bridge was washed away by this flow within about a day. Many townships were under water and all the infrastructure of the areas including schools, colleges and other small industrial establishments were severely damaged also washing away temples, houses, water animals, ducks and cattles. River Beki also got choked from this point downstream. The entire flood season passed in this manner with rise and fall of water levels of these rivers. The most famous more than 500 years old Barpeta Kirtan Ghar, was partially submerged including the district headquarter town of Barpeta. Till the early November 2004, the situation did not improve all that much, many human lives were lost through accidents. The course of Kalapani increased to the size of a regular River due to obvious effect of retrogression.

Some works to reactivate the original courses of Manas and Beki and to close the breach at Narayanguri has been taken up but more work is necessary for full development of the courses and to maintain the natural ecology and to protect the Manas National park.

River Beki: The River Beki crossed the danger level of 45.38 meters on 08.07.04 and was flowing above danger level up to 18.07.04 attaining a maximum level of 45.96 meters on 11.07.04 at Rd. Bridge.

Goalpara District:

Flash Flood of Jinari River: (Source Water Resource Department, Assam, 2010)

In the month October 2004, the Balbala flash flood tragedy consumed about 250 human lives; property and live stock worth crores of rupees were also destroyed.

The occurrence of this heartbreaking catastrophe was mainly due to a cloud burst over the hills of the neighboring state of Meghalaya. The intense rainfall activity during those days over the Meghalaya hills and neighboring areas of Assam made the Jinary river volatile leading to the disaster. In the absence of interstate rainfall data, the intensity of rainfall over the Meghalaya Hills and Assam areas during those days could be judged from the rainfall data of Goalpara Town for that period. Goalpara Town experienced a rainfall of 438.9 mm. between October 4 and 12 that year and during day hours of October 8, there was rainfall of 223.6 mm over the town. This sort of rainfall activity over Meghalaya and Assam upset the hydrological system of Jinary River, a southern tributary of the mighty Brahmaputra. Balbala is located around 4 km upstream of the confluence point of the Jinary and the Brahmaputra.

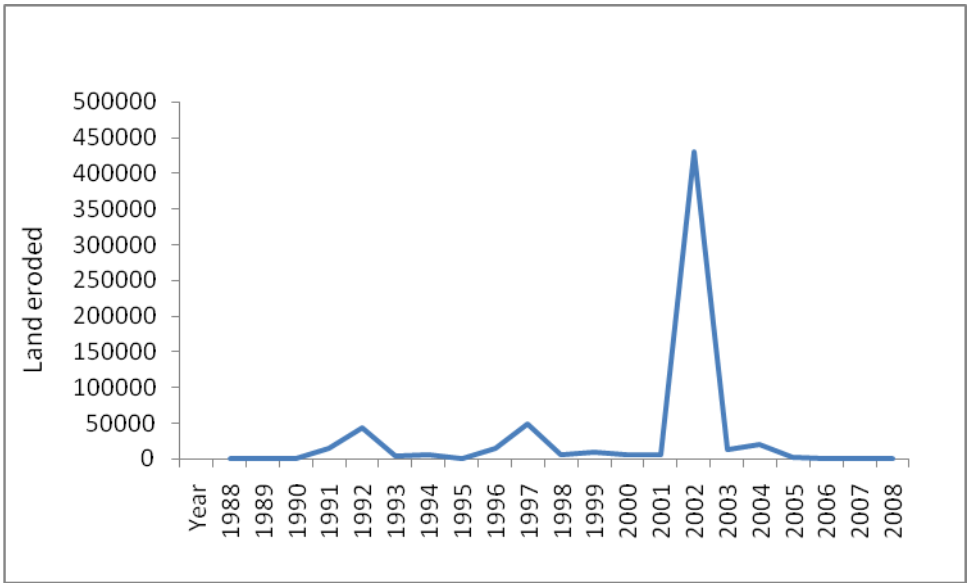
Jinary is a narrow channel with the maximum width of only 137.56 m near its confluence point with the Brahmaputra. It has a 567 Sq. km. Basin of which 191 Sq. km falls in Assam and the rest 376 Sq. km is in Meghalaya. Its length is 75.89 km in Assam and 42.21 km in the state of Meghalaya. In Meghalaya it is known as Remba Chimba or Didram. The middle part of the channel shows a tendency of lateral shifting and at places it has shifted laterally up to 172.87 m between the years 1967 and 1998. In addition to incisive rainfall in the upper catchment area of the Jinary basin, railway line and roadways acted as major barrier to rushing waters of the river.

Massive deforestation and unplanned human settlements also played major roles making the basin a flood prone area. In 1968 dense forest constituted 402.36 Sq km i.e. 70.96% which is 65.39% of the basin area in 1998. Now only 50.57 Sq km of the area of the basin is under dense forest cover while the remaining 320.18 Sq km area is under degraded forest. Thus, the rapid decline in the density of forest cover is a major factor contributing to flash floods in the river basin where drainage density is as high as 2.47 km per Sq. km with little natural forest barrier.

There was breaching reported from the West embankments of the Jinary at Kokiara about 5 km upstream from Balbala about one month ahead of the Balbala tragedy. This led to inundation of crop land in Kokiara area also provoking the Balbala calamity. During Balbala incident, crop area of about 30 Sq. km was damaged, although the Jinary inundated the flood plains earlier but its severity was much less as it could easily overtop the National Highway 37 which was very low till 1990-91. Ever since its importance grew with the construction of Naranarayana Setu over the Brahmaputra, its level was raised by around 3

meters on an average between Agia paharkata and Balbala. On October 7, 2004 the flood waters of the Jinary simply wiped out about 20 villages on an area of about 4 Sq. km, these villages were located on the rivers' flood plain area.

7.1.3 River bank erosion



Another major hazard that is facing Assam is the erosion of land that has been going on unabated since a long time. The soil around the river bank is generally sandy and when the rivers erodes the bank line huge chunks of land falls into the river and are lost. This has been going on every year after year and in 2006 about 821.83 hectares of land has been eroded damaging property worth a crore (Water Resources Department Assam, 2006). The large scale damages associated with floods further exacerbated by river bank erosion destroys an annual average of about 8, 000 hectares of riparian land along the Brahmaputra (River Flooding and Erosion in Northeast India, 2006). The graph below indicates the amount of land eroded since 1998 to 2008.

According to the Second National Communication to UNFCC, 2010, 3, 86,000 hectares of land have been eroded affecting 90, 000 families and 2,500 villages. An area of 4, 29,657 hectares has been eroded (Water Resources Dept, Government of Assam). The denudation of forests and vegetation cover has exacerbated the problem of river bank erosion creating a vicious cycle of environmental degradations (Das, Chutiya & Hazarika, ICIMOD, 2009). Since 1954, the total area eroded is 386,000Ha, the rate of erosion is estimated to be 8,000Ha/year, and the numbers of villages eroded are at 2,534 with 90,700 families affected (Water Resources Department, Government of Assam).

7.1.4 Sand deposition/casting

Sand casting or deposition has become increasingly devastating since the mid 1990's, especially in the northern banks of eastern Brahmaputra valley (Das, Chutiya & Hazarika, ICIMOD, 2009). Although, at present it has resulted as a disaster only in certain pockets of central and lower Assam, it can be recognized as an emerging risk for the state. Human management of landscape within the Brahmaputra basin is presently implicated as a major factor controlling the regional runoff, discharge regime and erosion plus transport. The river

is ranked fourth among the largest rivers of the world wide with an average annual discharge of 19, 830 m^3/sec. In terms of sediment transport, it is second only to the yellow river (Hwang Ho) with a sediment transport per unit drainage area of 1128 metric tons per sq km. The acceleration of this erosion and transport of sediment is closely associated with the land use and land cover change in the basin area (as informed by team of experts in Chief Engineer's Office,Water Resources Department Assam). It has already led to degradation of thousands of acres of farmlands and wetlands. Deforestation and increased pressure on land due to explosion of population is a major cause of this apparent increase in sediment yield. Thus, the Brahmaputra basin has witnessed numerous anthropogenic activities like deforestation conversion of natural system to agriculture, wetland destruction (as informed by team of experts in Chief Engineer's Office, Water Resources Department, Assam).

Effective adaptation measures are yet to be developed at the community level with respect to sand casting, since the phenomenon is relatively new to the people of Assam (Das, Chutiya & Hazarika, ICIMOD, 2009). In Dhemaji and Lakhimpur districts, the problem of sand casting in agricultural lands has proven to be an irreversible one which has led to cascading effects in loss of livelihoods, migration and even sporadic protests.

7.1.5 Landslides

Landslides and floods are the two most pervasive natural hazards that undermine the urban development of Assam (Assam Staff College Report, 2005). Landslides are also a cause for devastating floods that may occur by sudden breaching of temporary dams that are formed by landslides (Das, Chutiya & Hazarika, ICIMOD, 2009). The earthquake of 1950 triggered large landslides which dammed the tributaries of the Brahmaputra River like the Dihang, Dihing and Subansiri causing devastating floods downstream rendering 1,526 deaths, destruction of 70 villages and great changes in the topography (Assam Staff College Report, 2005). Temporary dams formed landslides can cause liquefaction damage in areas where the river enters the plains. Landslides are a major contributor to the sediment load of the river causing aggradations of the river beds and reductions in the carrying capacity resulting in inundations of the surrounding lowlands during high summer flows (Assam Staff College Report, 2005). Activities like building roads are believed to be the worst form of human intervention to promoting soil erosion and landslides as large amounts of debris are removed for the construction purposes (Assam Staff College Report, 2005). Encroachment in hill areas of Guwahati, Sonapur and clearing of slopes for jhum cultivation in North Cachar are some of the causes for landslides in those area (as informed by Disaster Management Cell, Revenue and disaster management department)

7.1.6 Cyclonic Storms

The instances of cyclonic storms have increased in its severity in the western regions of Assam especially during the monsoons. At times these cyclonic storms can be devastating bringing colossal losses to human lives and property (Assam Staff College Report, 2005). A total of 24 districts were affected in 2010 from storms namely-Karimganj, Cachar, DaRANG,

Jorhat, Morigaon, Dibrugarg, Hailakandi, Sonitpur, Barpeta, Bongaigaon, Kokrajhar, Dhubri, Sivsagar, Nalbari, Kamprup, Chirang, Golaghat, Nagaon, Karbi Anglong, Goalpara, Kamrup Metro, North Cachar Hilla, Udalguri and Baksa. Three thousand nine hundred and sixty one villages were affected and among 1.5 lakh affected people, there 45 deaths.

7.1.7 Forest Fire

The instances of forest fires were reported from 15 districts namely Barpeta, Karbi Anglong, Kamrup, North Cachar Hills, Cachar, Sonitpur, Bongoigoan, Darrang, Kokrajhar, Nalbari, Golaghat, Bongaigoan, Dhubri, Goalpara, Hailakandi and Nagaon. Forest fires during the period of March 12, 2009 were reported from Darrang, Kokrajhar, Nalbari, Barpeta, Bongaigoan, Golaghat, Karbi Anglong, Kamrup, Dhubri, Goalpara, North Cachar Hills, Cachar and Hailakandi with the maximum number of forest fires being reported from North Cachar Hills. During the period of March 13-15, 2009 forest fire were reported from Karbi Anglong, Barpeta, Kamrup, North Cachar Hills, Cachar, Sonitpur and Bongoigoan with the maximum number of forest fires being reported from the Karbi Anglong. During the period of March 08, 2010 forest fires were reported from Bongaigaon, Darrang, Dhubri, Golaghat, Kamrup, Karbi Anglong, Nagaon and North Cachar Hills with the maximum number of forest fires being reported from North Cachar Hills.

7.2 Challenges and Issues

The location of the river Brahmaputra is so significant that impact of global climate change would appear earlier here because of its sensitive nature as a geo-environmentally vulnerable watershed. The climate and environment over the Brahmaputra Basin to a large extent is controlled by the Asian Monsoon (Water Resources Department Assam, 2006). Being located at the transitional zones between different climatic regions and different distinct geomorphologies, such as that of the cold dry climate of the Tibetan plateau and the warm tropical humid climate of the Assam-Bangladesh plains, the temperature contrast would occur earlier than other regions. Apart from its role in the evolution and formation of the Asian monsoon circulation, the thermal and dynamic influence of the Tibetan Plateau affects climatic modulation of water-induced hazards like the annual flooding of the Brahmaputra and also impact the relationship between spatial distribution of water and intensity of such disasters (Mahanta et al., 2007).

The incidence of rain in Assam and its neighboring areas is exceptional heavy. This together, with some human activities like accidental release of dam water or natural surprises like sudden cloud burst as happened in Bhutan in 2004 results in wide spread damage in the downstream areas (Water Resources Department Assam, 2006). Anomalies in local and regional weather and climate triggered by global climate change have of late resulted in increase in occurrence of such hazards and consequent affect (ASTEC, 2011).

From our consultation process along with inputs from Assam Science Technology and Environment Council (ASTEC, 2011) we have identified the following issues which can aggravate the vulnerability of the people of Assam to the natural hazards -

i. Increase in sediment load of the major rivers of the state due to changes in land use and land cover patterns in the upper catchment areas

ii. Lack of proper measures to improve carrying capacity of the major rivers for mitigating flood and erosion risk

iii. Poor maintenance of the earthen embankments and dykes constructed to protect 1.63 million ha out of 3.15 million ha flood prone area of the state

iv. High rate of embankment breaching during monsoon period and sand deposition on agricultural land

v. Floods created by large river dams built to produce hydropower

vi. Landslide dam induced flooding from high hills of Tibet(China), Bhutan, Arunachal Pradesh and Meghalaya

vii. Quality of downstream impact assessment/environmental impact assessment and damage mitigation plan of the ongoing hydroelectric projects remains questionable

viii. De-stabilization of river beds by boulder collection; encroachment of wetland and natural reservoirs; permanent settlement in char areas (sand bars/island) of the rivers etc

ix. Enhancement of land slide risk in hilly ranges, including those around Guwahati city, due to encroachment.

x. Haphazard urbanization and absence of district disaster management plans (DDMP) for all the districts of the state based on hazard pattern and location specific risk assessment

xi. Non-implementation of Incident Command Systems in most of the districts

xii. Lack of training capacity for disaster preparedness in district level

xiii. Lack of coordination among governance institutions, academic institutions and vulnerable communities.

Adaptation need

Taking the projections of climate change along with the views of the stakeholders (ASTEC,2011) into account we perceive the following adaptation needs for the people of Assam.

i. Strengthening of the disaster response strategies in the district and lower levels of political jurisdiction

ii. Development of seed and fodder bank in flood prone areas

iii. Maintenance and close monitoring of existing embankments and their timely repair in case of sudden breaches with participation of local communities

iv. Preparation of village, Panchayat and block level inventory and contingency planning

v. Regulation on land use specially in issues of reclamation of wetlands and hill areas for settlement and other developments

vi. Formation of research consortia to study impact of climate change on Brahmaputra river system, livelihood diversification in regions of irreversible ecosystem change, construction of integrated database to facilitate situation analysis of any sector.

7.3 Existing policies/schemes/programs

The existing policy framework in response to the risks posed by various hazards can be explained under three heads-

Strategies for flood and erosion risk management

Majority of Assam's urban and agricultural area is located in the flood prone areas. Since the flood hazard proves to be disastrous in many parts of Assam, effective flood risk management remains high on the state's development agenda. The task is quite challenging given the dynamic morphology, erratic rainfall, and heavy sediment transport (Asian Development Bank, 2010). The state government of Assam through the Water Resources Department has extended embankments and associated structures to protect 50% of its flood prone areas (Asian Development Bank, 2010). Flood protection measures like building of embankments have served the purpose only on a short term scale leading to a more deleterious impact on the regime of the river especially leading to its aggradation (Assam Staff College Report, 2005). Thus, improving the reliability of the existing embankments systems with assured maintenance system should be given high priority (Asian Development Bank, 2010). Therefore, addressing the problem of floods calls for a comprehensive long term perspective sound policy and planning framework as advocated by the government (Asian Development Bank, 2010). The Asian Development Bank project for Assam Integrated Flood and Riverbank Erosion Risk Management Investment Programme focuses on the enhancement of the reliability and effectiveness of the flood and riverbank erosion risk management programme. The output of the investment programme will consists of Flood and Riverbank Erosion Risk Management (FREFM) planning, institutional and knowledge base, comprehensive flood and riverbank erosion risk management (FREFM) systems in the three subproject areas namely Dibrugarh, Kaziranga & Palasbari, and a multidisciplinary project management system (Asian Development Bank, 2003). The investment will be categorised into two projects, firstly the structural comprising the short term providing immediate investments on the three existing embankment systems, secondly, the non structural comprising of awareness campaign, improved warning, strengthened relief and hazard maps (Asian Development Bank, 2010).

Plans of the Brahmaputra Board

The Brahmaputra Board has also taken up drainage development schemes for effective flood control measures (Brahmaputra Board). The master plan by the Brahmaputra Board is being divided in to three main parts, first, for the main stem of Brahmaputra, second, for Barak River and its 8 main tributaries and lastly for the tributaries of the Brahmaputra. The Brahmaputra Board has undertaken Drainage Development Schemes for the effective

control of floods. The Brahmaputra Board has handed five drainage development schemes to the Flood Control Department, Government of Assam. According to the Water Engineering Works, Water Resources Department Assam, river control continues in earnest in the flood plains of the Brahmaputra River and is an important focal point for ongoing development efforts. These activities provide an example of the interrelationship between human activity and drainage basin hydrology. Starting from the first five year Annual Plan of India in 1951–1952, altogether 4,450.60 km length of embankment, 850.69 km drainage channel and 85 number of sluices were constructed in the flood prone area along with 653 number of town protection works which were taken up as a short term measures for protection against flood and erosion of the river Brahmaputra and its tributaries. The Brahmaputra Board has undertaken preparation of a master plan to ensure short and long term measures and solutions for protecting the Majuli Island from acute erosion problem (Brahmaputra Board).

The government has implemented several anti- erosion measures to contain the attack of the river banks or embankments, but the problem of erosion has increased in the recent years. An estimated area of 3, 86, 000 hectares has been eroded since 1954, which translates into an annual erosion rate of about 8000 hectares per year. This provides a major opportunity for converting critical flood prone agricultural lands into forestry plantations including bamboo plantations (Assam Water Resources Department, 2006). The government of Assam had taken up bank protection works for the last three decades (Assam Staff College Report, 2005).

This river engineering is certain to amplify the apparent variability of river discharge, flood plain and in-channel sedimentation processes. The effect of these structures on the fluvial process and environmental changes as a whole is least studied so far. If the increased magnitude and frequency of bank fall discharges in recent are any indications, it is of great geomorphic significance in the formation of flood. Dam building as a long-term flood and erosion protection measure as well as economic development has already made its mark and it is certain to play a significant role in the enormous water resources potential of the region.

Activities for disaster management

The Assam State Disaster Management Authority under the Assam State Disaster Management Policy, 2010 has been entrusted to design policies and plans for disaster management in the state, recommend the provision of funds for mitigation and preparedness measures, review the development plans of different departments of the state and ensure that the prevention and mitigation measures are integrated therein and issue guidelines as and when necessary (Assam State Disaster Management Policy, 2010). The institutional framework includes District Disaster Management Authorities (DDMAs) under the District Commissioners (DCs) and also local authorities like Panchayat Raj Institutions, Municipalities, etc.

In order to mitigate the flood devastation and help the communities reduce the losses, Assam State Disaster Management Authority (ASDMA) has been working towards developing a Flood Early Warning System in collaboration with the North East Space

Application Centre (NESAC) as the lead institute. The warning system has been tried on a pilot basis for 5 districts i.e. Lakhimpur, Dhemaji, Nalbari, Barpeta and Baksa during 2010 flood season. Flood warning through this system is issued to all concerned administrative agencies 24 hours in advance through email and SMS (ASDMA, Annual Report, 2010). In the pilot study, 90 percent success rate was observed in Dhemaji district (as informed in discussion with team in ASDMA). The ASDMA in collaboration with National Remote Sensing Centre (NRSC) and ISRO is working towards developing a tool for effective emergency response system for field personnel where distress messages, emergency messages, first information report and summary reports from the field can be communicated. A prototype of a National Database for Emergency Management (NDEM) has been prepared in 2010. Another pilot study under the GoI-UNDP Disaster Risk Reduction Program, for Hazard risk and Vulnerability assessment has been initiated by ASDMA with collaboration with NESAC for Dhemaji district, Guwahati city and Silchar towns. After the 2010 floods, a review of the breaches in the embankments was conducted under the chairmanship of the Chief Secretary, Government of Assam and involving CWC and the Brahmaputra Board (ASDMA, Annual Report, 2010). An initiative for mapping the embankment breaches using remote sensing has been taken up by the ASDMA and preparation of a Flood Hazard Atlas is under preparation (as informed in discussion with team in ASDMA). The department is also setting on an integrated plan involving stakeholders like Central Water Commission (CWC), Water Resource Department and India Metrological Department (IMD) to revisit the danger levels of the major rivers of Assam as the river beds have risen due to aggradation.

The Assam Relief Manual, 1976 does not include strategies for disaster preparedness, thus the Revenue and Disaster Management Department is in the process of revising this manual as a Disaster Management Manual through consultations with concerned decision makers as well as civil society organizations. For capacity building, the ASDMA has equipped 25 flood prone districts with 100 rescue boats made of inflatable rubber and fibre reinforced plastic in 2010. In order to create capacity for response beyond the district level ASDMA has also set up a Revenue Circle level Disaster Information and Response Centre on a pilot basis in 5 districts i.e. Kamrup, Kamrup metro, Lakhimpur, Dhemaji and Dibrugarh. For awareness generation mainly for earthquakes and local responses, ASDMA has teamed up with Non Governmental Organizations, hospitals and District administrations for effective participation. Under the GoI-UNDP Disaster Risk Management programme, Disaster Management Teams (DMT) are formed in the village level where women are included as master trainers. For health concerns during disasters, a pilot project of Social Health Activists was initiated in Nagaon district where the volunteers were links between the villagers and the public health centres. Such volunteers were part of the DMTs and were treated as change agents by the project as they shared a rapport with their individual communities.

Gap analysis

The risks of the natural hazards and vulnerabilities towards them may increase and may also be felt differentially according to varying contexts due to a range of climatic and non-

climatic factors. Deforestation, urbanization, and reduction of wetlands diminish the available water storage capacity and increase the runoff coefficient, leading to increase of the flow amplitude and reduction of the time-to-peak of a flood triggered by an intense precipitation. In addition, the intensity of precipitation is very likely to change in the future, due to global climate change phenomenon. Furthermore, human encroachment into unsafe areas has increased the potential for damage. Societies become more exposed to hazards as they settle and develop hazard-prone areas.

Each of the natural hazards has the potential to create havoc by its own but there are linkages between them and there is gap in the understanding of their causality chains. In addition, climate change has the potential to change the risks from these hazards by altering their frequency and magnitude. In the midst of this uncertainty, it is difficult to come up with stand alone policies for mitigation and adaptation to these hazards. Under such a scenario, a relevant policy framework for disaster management is to mainstream the emerging risks into the ongoing management and development programs.

The paradigm shift, from relief centric responses to one of boosting preparedness among the masses, offered by the Assam disaster policy, 2010 is one in the right direction. However the aim of an integrated approach set out by the policy remains a challenge until the management of flood is visualized as a holistic cycle consisting of- Prevention, Protection and Preparedness (Kundzewicz et al., 2010). A lack of institutional mechanism to incorporate the ongoing projects related to the three elements under a common agenda may again lead to piecemeal solutions. Such solutions may be desirable by just one group of experts and decision makers but the lack of a systemic understanding may increase long term risks to same or other sectors.

7.4 Actions and strategies

Following the approach by Kundzewicz et al., 2010 and also keeping the inputs from stakeholders (ASTEC, 2011) in mind, we offer a way forward for action strategies for climate change for Assam

a. Prevention can be understood as preventing flood damage by avoiding construction of infrastructure in present and future flood-prone areas (e.g. restriction of settlement in risk areas); or by adapting future developments to the risk of flooding. Legal regulations can be implemented, related to use of flood-plain areas, such as restrictions on new infrastructure. The need for costly defense and relocation measures, e.g., relocating industry and settlements from flood plains may be envisaged. In this regard the Flood Hazard Atlas under preparation by ASDMA is the first step. Flood prevention may also include modification of construction standards. A small-scale structural action is flood-proofing on the site, i.e. adapting existing building codes to ensure that long-term infrastructure withstand future climate risks.

b. Protection means taking measures to reduce the likelihood of floods and/or the impact of floods in a specific location, e.g. via dike strengthening or heightening,

or creating storage room. Some of the structural measures are being planned under the ADB project (FERM) but such interventions have been found to change the natural flow regime which adds future challenges. In this regard, there have been experiments on bioshielding of river banks using species like Vetiver (*Chrysopogon zizanioides*). There has to be research for scaling up of such activities including studies on usage of some indigenous species for erosion control. Another option here is of restoring the old wetlands and stream flows, mainly in the urban areas, to enhance the drainage of the flood water and reduce water logging.

Detection of changes in long time series of flood and/flood damage data is an important scientific issue, fundamental for any situation analysis and planning of future water resources and disaster protection. However the data sets required for such analysis is not appropriate for any of the sectors. Studies should be initiated to integrate existing information to come up with an integrated database. Moreover existing infrastructure, e.g. dikes and check dams may not guarantee the adequate level of protection and may need to be re-adjusted considering a climate change scenario. However, it is a technical challenge of detecting and attributing a climate change signal in flood records and vast uncertainty in the projections itself. In this regard research has to be undertaken, in collaboration with climate modellers, for a different approach regarding the design floods of the management institutions (eg.100 year floods) (Kundzewicz et al., 2010).

c. In preparedness, a resilience approach has to be undertaken wherein; the society is trained and given options to stay flexible in order to cope in the face of irreversible ecosystem changes. For example as agricultural lands are being totally lost due to sand casting in northern bank of Brahmaputra river, options for livelihood diversification is becoming very essential for subsistence. In absence of such programs mass scale migration and even sporadic agitations are observed. There has been local experiments elsewhere of chilli, lemon, corn etc. cultivation in sand and hence research has to be taken up on validation and means of scaling up such alternate crops. The implementation of such programs can be integrated into ongoing agro-biodiversity programs by Assam Agricultural University. The ASDMA should take a lead on projects involving research consortia and take an initiative in involving all stakeholders from experts, decision makers of concerned departments to local NGOs and user groups.

   Preparedness also includes forecasting and information, insurance schemes, and providing instructions to the public on what specific actions to undertake in the event of flooding. Work has been initiated by ASDMA on many fronts, in pilot scale in partnerships with NESA and also with some Non Governmental Organizations for grass-root level capacity building. However, it will be very important to monitor the transition of the projects from the design phase to the

implementation phase. This will initiate a learning process during implementation which can again pave the path for efficient and effective performance of such and other projects elsewhere. A robust system of feedbacks from the participants must be incorporated within the training programs in order to make the collaborative programs accountable, transparent, flexible and hence acceptable.

	THRUST AREA 5: Disaster
	Strategies
Research and technology development	Some of the structural measures are being planned under the ADB project (FERM) but such interventions have been found to change the natural flow regime which adds future challenges. In this regard, there have been experiments on bioshielding of river banks using species like Vetiver (*Chrysopogon zizanioides*). There has to be research for scaling up of such activities including studies on usage of some indigenous species for erosion control.
	Detection of changes in long time series of flood and/flood damage data is an important scientific issue, fundamental for any situation analysis and planning of future water resources and disaster protection. Studies should be initiated to integrate existing information to come up with an integrated database.
	Moreover existing infrastructure, e.g. dikes and check dams may not guarantee the adequate level of protection and may need to be re-adjusted considering a climate change scenario. However, it is a technical challenge of detecting and attributing a climate change signal in flood records and vast uncertainty in the projections itself. In this regard research has to be undertaken, in collaboration with climate modelers, for a different approach regarding the design floods of the management institutions (eg.100 year floods)
	There has been local experiments elsewhere of chilli, lemon, corn etc. cultivation in sand and hence research has to be taken up on validation and means of scaling up such alternate crops. The implementation of such programs can be integrated into ongoing agro-biodiversity programs by Assam Agricultural University. The ASDMA should take a lead on projects involving research consortia and take an initiative in involving all stakeholders from experts, decision makers of concerned departments to local NGOs and user groups.
	If the increased magnitude and frequency of bank fall discharges in recent are any indications, it is of great geomorphic significance in the formation of flood. The implication for dam building as a long-term flood and erosion protection measure as well as economic development needs careful study.

	Need for instrumentation of the departmental infrastructures providing irrigation to keep vigil on the parameters associated with emerging climate change issues
	Risk assessment of the hydrometeorologial extremes of floods and droughts in order to strengthen the existing hydraulic systems
Policy measures	Legal regulations can be implemented, related to use of flood-plain areas, such as restrictions on new infrastructure or mandatory climate risk assessments for proposed infrastructure.
	In disaster preparedness, the resilience approach needs to be emphasized in Disaster Management Manual which under preparation by the Revenue and Disaster Management Department. The Assam Relief Manual, 1976 requires a comprehensive revision to deal with climate change risks.
	The need for costly defense and relocation measures, e.g., relocating industry and settlements from flood plains, may be envisaged for high risk zones.
	Policy support for restoration of the old wetlands and stream flows, mainly in the urban areas, to enhance the drainage of the flood water and reduce water logging.
Institutions and governance	Strengthening of institutions and the disaster response strategies in the district and lower levels of political jurisdiction
	Preparation of village, Panchayat and block level inventory and contingency planning. There are 89 Urban Local Bodies in Assam amongst which 56 Urban Local Bodies are prone to flood
	Maintenance and close monitoring of existing embankments and their timely repair in case of sudden breaches with participation of local communities

Capacity Building	Preparedness also includes forecasting and information, insurance schemes, and providing instructions to the public on what specific actions to undertake in the event of flooding. In pilot scale, work has been initiated by ASDMA regarding Hazard risk and Vulnerability assessment under the GoI-UNDP Disaster Risk Reduction Program and also in early warning systems for floods in partnerships with NESA and also with some Non Governmental Organizations for grass-root level capacity building. An initiative for mapping the embankment breaches using remote sensing has been taken up by the ASDMA and preparation of a Flood Hazard Atlas is under preparation. The department is also setting on an integrated plan involving stakeholders like Central Water Commission (CWC), Water Resource Department and India Metrological Department (IMD) to revisit the danger levels of the major rivers of Assam as the river beds have risen due to aggradation. These collaborative programmes need to be scaled up with proper monitoring, evaluation, and feedback from local stakeholders.
	Disaster management must be introduced in school and/college curriculum
	Disaster management by training on public health emergency management specifically with reference to climate extremes

Chapter 8: Health

8.1 Current status and recent trends

Some districts of Upper Assam, Lower Assam and the Hill Districts along with areas near international borders are declared as endemic areas for vectore borne diseases such as Malaria, Japanese Encaphalities and Filaria. The Urban areas are endemic to Dengue and Chikungunya. Under-nutrition and malnutrition are prominent along with presence of iron-deficiency and Anemia among children and women in Assam. In addition, Anemia due to Hb E and Sickle Cell Anemia is common among indigenous tribal and tea-tribes respectively and also among the general population. With the disappearance of surface drinking water, people of the State are depending more upon deep tube well water, whose contents are very high in toxic substance like fluorides, which is found in the underground water strata rich in limestones. Fluorosis is particularly rampant in the Districts of Karbi-Anglong, Kamrup (R), Kamrup (M), Golaghat, Karimganj and Nagaon. So, processed drinking water for the public having all the micro-nutrients beneficial for health will be a major problem including the "0" level Florides. Non communicable diseases like mental diseases, diabetes, hypertension and occupational hazardous diseases like cancer, silicosis etc. also pose as health hazards of the State.

In Assam malaria, filarial, acute encephalitis syndrome (AES)/JE and dengue are prevalent, out of which malaria, AES/JE and dengue are epidemic prone diseases. The following table provides a record of malaria situation in the state-

Year	Total positive cases	Percentage cases increase in comparison to previous years	Death	Percentage of death increase in comparison to previous year
1995	230702	43.7%	202	193%
1999	131048	38.5%	111	226%
2006	126178	85.8%	304	169%

AES/JE is endemic in few districts of Assam. Due to improve surveillance, the case detection is increased from 64 in 1996 to 643 cases in 2009. However case fatality is decreased from 45.31% during 1996 to 16.95% during 2009. Case fatality is recorded more than 40% during 1996, 2000, 2001 and 2003. Dengue emerges as epidemic form during 2010 and no incidence was recorded prior to 2010. Japanese encephalitis was uncommon before the 1960s, but started occurring since early 1970s and gradually became a childhood fatal disease in 1990s. However, recently since last 5years have demonstrated an age shifting as it is affecting adult population with a case fatality rate up to 37%. Diphtheria is also showing increasing trend with age shifting affecting maximally 20-40 years age group. Post flood measles outbreak and more prevalence of nutritional disorder are found in Assam.

8.2 Challenges and issues

A. Availability to safe drinking water- Number of habitations with 100 percent population coverage for safe drinking water is 46262 out of total number of 86976 habitations

B. Sanitation in rural areas needs improvement, for eg. kutcha latrines need to be converted into sanitary latrines

C. Less environmental awareness among the rural community

D. Absence of proactive involvement of different stakeholders

E. Rural communities aspiring more for the Govt. subsidy for constructing households toilets and other sanitation latrines

F. Absence of effective inter- Sectoral convergence

G. Natural calamities

H. There is differential access to sanitation in rural Assam due to lack of awareness, resources and also mindset of masses

I. There are certain areas in Assam, where providing sanitation facilities pose a great challenge especially in the Char areas, where sub-soil water level is very high and there is migration from low lying areas to other high lands during floods

J. All districts of Assam are affected with iron. Four districts-Jorhat, Kamrup, Karbi Anglong and Nagaon are affected with Fluoride. 19 Districts out of 26 are affected with arsenic with Jorhat with the highest affected habitations.

8.3 Climate change perspective: the need for adaptation

The findings of INCAA, 2010 demonstrate that in 2030s most of the districts in NER have transmission windows open for 10-12 months, and very few have transmission windows open for 7-9 months, indicating greater stability of malaria transmission in these states. In Assam, while only 2 districts (out of 19 for which data is available) have transmission window open for 10-12 months in the baseline scenario, in the projected scenario 14 districts fall in this category.

8.4 Actions and strategies

These are presented in the following table

	THRUST AREA 4: Health
	Strategies
Research and technology development	Assess vulnerability hotspots (spatially & temporally) with respect to changes in the climate to identify regions and populations at risk of climate-sensitive diseases in the state
	Mapping changes in vector ecology relative to a changing climate
	Conduct studies to assess links between climate change and malnutrition through changes in nutritional content of crops
	Use remote sensing techniques to assess linkages between climatic variables, vegetation cover and malaria incidence
	Procure and customize health impact models for climate and health impact assessments in the state
	Conduct predictive modeling using high resolution meteorological data (observed and projections) for the region and establish the links with epidemiological parameters
	Develop and maintain a digital health database at fine spatial and temporal scales particularly for mortality and morbidity related to climate sensitive Vector-Borne Diseases, water borne diseases, and those related to higher temperatures and rainfall extremes
Policy measures	Budget support for public health emergency preparedness in case of climatic extremes
	Strengthen anticipatory efforts such as vaccination, distribution of mosquito repellants, bed-nets and antibiotics in areas prone to malaria
Institutions and governance	Bringing greater convergence amongst programs in the health and non-health sectors to buttress primary
	Improve the quality of data
Capacity Building	Upgradation of rural healthcare infrastructure to deal with emergencies during climatic extremes, especially in remote districts/areas (e.g. chars)
	Generation of awareness among the rural masses about the water quality issues and the problems related to water borne diseases

	Promote health education and awareness with respect to climate risks and adaptation through schools and CBOs
	Scientific/Technical training to health sector staff for example, epidemiologists, to carry out research in vulnerability and impact assessments: use of retrospective as well as forecasting/predictive techniques, models and software
	Training of volunteers on public health emergency management
	Promotion of public awareness about healthy and sustainable lifestyles
	Rain water harvesting structures in rural areas to use for drinking purposes including recharge structures

Chapter 9: Bio resources

9.1 Current status and recent trends

Assam has a diversity of wild and domesticated biodiversity including agriculture and livestock, apart from its immense forest and wetland wealth. The enormous and diverse bioresources of the State have the potential to yield high economic returns for the people of the State if sustainably managed. The State's bioresources also offer a diversity of mitigation options to reduce the potential impacts of climate change. The conservation and management of Assam's forests, wetlands and biodiversity as they pertain to the livelihood strategies of local communities has been discussed in Chapter 9 on Sustainable Livelihoods. Here we discuss the bioresources of the State in the context of a mitigation perspective with a focus on agri-biodiversity, biomass and livestock as well as sustainable forest management.

The forest cover of the State (satellite data of Oct 2006-Jan 2007 is 27,692 sq. km (FSI, 2009) accounts for 35.3 % of the country's geographical area and fulfils the minimum criteria of 33 % forest cover as stipulated by the National Forest Policy, 1988. The forest resources of the State have already been discussed in an earlier section and the biomass potential is well acknowledged.

Assam along with its neighbouring North-Eastern States is a centre of diversity of various horticultural and cash crops including rice. Of about 12256 collections of rice germplasm maintained at the Central Rice Research Institute, 2054 are from Assam (Paroda and Sharma 1986). Unfortunately, the loss of native rice germplasm is likely to accelerate in the future as traditional varieties are replaced by modern, improved varieties. Similarly, a variety of grain legumes such as Blackgram (Vigna mungo), and Green gram (Vigna radiata) are found in North East India with significant variability, but there have been few efforts made for their conservation or collection despite their potential value for resistance to disease or insect pests or ability to adapt to varied temperatures or environments. Assam is also rich in citrus and banana germplasm and the occurrence of aquatic fruits like gorgon (Eurale ferox). The north east is believed to be the centre of hybridisation of Musa acuminata with the indigenous M. balbisiana believed to have evolved on the Assam-Myanmar border. This has resulted in high cultivar diversity of Musa along with various wild banana species such as Musa velutina and Musa glauca (Assam Science Society, 2002). The State also has a diversity of wild citrus forms.

Assam has a variety of indigenous breeds of livestock and poultry that are well suited to hot and humid climates, and are disease and pest resistant. In Assam, livestock and poultry populations have been increasing over the years. Various indigenous breeds, however, have declined or -several of these including the Bachaur, Dangi, Kherigarh and Siri varieties of cattle or various sheep including the Karnah, Poonchi, Hissardale, etc. are in urgent need of conservation(Assam Science Society, 2002) . The large livestock population of the State can be tapped as a potential source of biowaste that can be used for energy generation.

India generates over 370 million tonnes of biomass every year. In addition to the direct harvesting from plants, biomass is also produced as a by product in many agro based industries such as rice husk from rice mill, saw dust from saw mill, bagasse from sugar mills. Other sources of biomass include animal manure, aquatic plants and municipal

organic waste. It has been estimated that about 17 GW of power can be generated through cogeneration, combustion and gasification routes from the available biomass (Chauhan, 2010), all of which will help reduce emissions from Green House Gases (GHG). Assam is a rich potential source of biomass based energy production whose enormous potential is yet to be fully tapped.

9.2 Challenges and issues

- The rich germplasm of the State, an invaluable asset for the development of disease resistant, superior crop varieties is under increasing threat from climate change, habitat destruction and replacement of indigenous germplasm with high yielding varieties. This can lead to the loss of genetic diversity and increased vulnerability to climate change.
- Similarly, hardy, indigenous varieties of livestock are being replaced by modern varieties. There is a need to stem the loss of various indigenous breeds of livestock and germplasm.
- Tapping into the rich bioresources of the State in terms of biomass energy production, bioprospecting, biodiesel production and ecotourism is imperative to ensure reduced vulnerability of the State and its people to climate change, to ensure resilience and tap into ways to reduce GHB emissions.
- In addition, pressures on Assam's forests need to be reduced including encroachment, degradation, illegal logging and unsustainable extraction of forest products. This will ensure that Assam taps into the potential under REDD plus (Reduced Emissions from Deforestation and Degradation).
- Biodiesel provides an important opportunity for Assam especially given that Jatropha is found in abundance in Assam on roadsides, wastelands and village boundaries and can be grown in poor soils.

9.3Climate Actions and Strategies

Developing the State's bioresource potential is a critical area of development especially, the role of fresh water and forest biomass for carbon storage, bioprospecting, development of eco-tourism and non timber forest products. The following table presents the strategies for the SAPCC on bio-resources.

	THRUST AREA 2: Bio-resources
	Strategies
Research and technology development	Species specific studies to determine carbon sequestration potential and exploring international mechanisms such as CDM, and REDD plus to get economic incentives
	Identification of appropriate species for energy plantation such that Assam's waste land could be potentially used (For example Out of total geographical area of 78,438 sq.km, Assam has 14,034 sq km of waste land -Potential land for Jatropha plantation is around 0.46 million hectare, potential of producing 2.3 million litres of biodiesel per day or 759 million litres of biodiesel per year)
	Detailed technical assessments to assess the potential of energy generation and economic viability from available biomass and livestock waste
Policy measures	Measures to improve development of species of economic importance and with sequestration potential
	Adoption of sustainable forest management practices to arrest the increasing trends of degradation and enabling reforestation
	Biomass of local species could be used for thermal applications in sectors such as tea withering and drying, bakery, brick kilns, pottery kilns, industrial dryers and boilers etc. Incentives to promote use of such applications to attract investments is required
	Assam has large number of livestock and poultry, incentives to harness full potential for waste management and energy co-benefits (For example community kitchens or hostel kitchens with bio-gas generation from waste)
	Exhaustive biomass policy/ revival of biogas plants schemes
Institutions and governance	Identification of responsibility centers and enabling community level engagements for renewable such as biomass, biogas
	Introduction of improved chullas for preparation of mid day meals in all schools and anganwadi centres along with fuelwood tree plantations
	Increased role of forest corporations for value addition and marketing of products from identified species
Capacity Building	Sensitization and capacity building of SHGs for propogation of improved chullas and biogas plants
	Capacity building and skill development of local communities
	Awareness generation- rural nodal agencies, local bodies, communities

Chapter 10: Urban Planning

10.1 Current status and recent trends

The rate of growth of population in Assam clearly outpaced the average rate of growth of population of the rest of the country during between the years 1901 to 2001, with more than a third of its population living below the poverty line. The rate of urbanization during this period was also faster than that of India, yet, Assam is still much less urbanized (12.7% in 2001) than the rest of the country (Assam Human Development Report, 2003). There is a clear rural-urban divide in its population, with two out of five people in rural areas living under poverty line while in the urban areas the occurrences are less than one in ten. The high rate of large-scale in-migration of males from rural to urban centres has been observed in districts like Kamrup and Tinsukia.

The recent trends observed in the development of Assam are the rates of urbanization which increased from 11.10% in 1991 to 12.72% in 2001. The number of classified towns increased from 93 in 1991 to 125 in 2001 and the percentage of urban population increased from 11 to 13 % in the same period Coupled with this urbanization, the tertiary sector in Assam which includes transportation has registered a higher growth rate of 2.29% as opposed to the primary sector which includes agriculture and the secondary sector which includes industries respectively (Assam Human Development Report, 2003). The state has observed a rapid increase in the population of motor vehicles the registration of which recorded a 23% increased during the year 2008-2009 over the previous years (Assam Development Perspective, 2011).

10.2 Challenges and Issues

Based on the approach to State Action Plan on Climate Change and the consultations with the Directorate of Urban Planning and the Directorate of Town and Country Planning, the following three priority areas of concern have been identified that harbour the key challenges related to urban development in the context of climate change:

- Waste Management
- Transport
- Buildings

10.2.1 Waste Management:

The increasing pace of urbanization in Assam, given the high rates of rural to urban migration and progress in the primary, secondary and tertiary sectors of the economy, together with the limited provision of urban services and amenities has resulted in an urban sprawl giving rise to increased environmental degradation. The changing urban consumption patterns in view of economic development have resultd in an increase in the waste generation and it is estimated that about 11,5000MT of solid wastes are generated daily in India (The Solid Waste Management Sector in India, 2009). According to an assessment made the per capita waste generation is increasing by 1.3% per year, and with the growing urban population ranging between 3 to 3.5% per annum the annual increase in the waste generation is estimated at about 5% (The Solid Waste Management Sector in India, 2009). In Assam, The Municipal Solid Waste generation rate is as follows:

Number of Cities	Municipal Population	Municipal Solid Waste (t//day)	Per Capita Waste (kg/day)
4	878, 310	196	0.223

Source: Saxena S, Srivastava RK, Samaddar AB, 2010

Garbage disposal has been one of the acute problems in the city of Guwahati, owing to the sheer lack of house to house collection of waste, secondary collection and most importantly the absence of permanent scientific dumping ground (Assam Development Perspective, 2011). This is by and large the scenario for all urban areas in Assam. None of the cities and townships in Assam have appropriate infrastructure for sewage treatment and this is a key issue for the sustainability of water resources on which the urban areas are dependent. Additionally, some of the major issues in waste management and applicable to the State include the following:

a. Lack of knowledge of Local Bodies: Most of the municipalities are often not aware of the ways and means to dispose solid waste that are generated, usually adopting a casual approach to the management of solid waste.

b. The non availability of suitable land for solid waste disposal in an environmentally friendly manner: In many towns no land is earmarked for the disposal of solid waste, nor as a landfill site or disposal through any other techniques. The location of the land plays an important role; hence it should be located in such a way that the solid waste is disposed in a decentralized manner.

c. Lack of Public Awareness: People are often unaware of the ill effects of solid waste being littered around in towns. There needs to be public awareness generated in this regard.

d. Non availability of funds and labour problems: Local bodies also lack the funds that are required to dispose of solid waste in a scientific manner. Most of the local bodies are dependent on their own staff for handling of solid waste which can result in labour related problem. A major proportion of the revenue is eaten away by a way

of paying wages, operation and maintenance (Ministry of Urban Development, Government of India).

e. Piecemeal approach for handling of solid waste: Local Bodies do not have any Waste Management Plans for their towns or cities; therefore there is substantial ignorance in this regard, thereby following a piecemeal approach.

10.2.2 Transport:

The rapid increase of the number of motor vehicles in Assam has been observed in the past few years. The vehicular population in the state reached 1236257 in March 2009 as opposed to 1165210 in March 2008. An additional 119126 vehicles were added in 2008-2009 as against 96796 in 2007-2008 (Assam Development Perspective, 2011). This increased population of vehicles on the roads means an increase in the fuel demand.

10.2.3 Buildings:

According to the IPCC, building related emissions account for nearly 30% of the total CO2 from energy use with 19% from the residential sector and another 10% from the commercial sector. The global CO2 emissions resulting from energy use in buildings have increased at an average rate of 2.7% per year during the period 1990-2004. (Source: www.teriin.org).

10.3 Climate change perspective: mitigation opportunities

The preparation of detailed city-level waste management plans with identification of land for waste treatment and disposal is a pre-requisite for sustainable waste disposal/management . In the transport sector, the use of public transport system should be encouraged to ease off the pressure of vehicles on the roads, hence, reducing the level of emissions and contributing to health benefits. The adoption of the Bus Rapid Transit system may also be considered for an orderly functioning road transportation system in Guwahati.

In the building sector, the adoption of the Green Building concept as opposed to conventional buildings need to be considered. This could prove to be a sustainable and a prudent approach to level off the building related emissions and energy consumption. A green design can save energy up to 40 to 50%, save water up to 30 to 40%, provide a healthy comfortable indoor environment, has minimum impact on people and catalyse healthy and productive work environment. A green design can bring in a minimum demand for resources (energy, water), improved quality of indoor environment, supply of renewable sources, and usage of very little water, promote recycling and reuse of water and enable solid waste segregation management and generation of resources from wastes. India has its own Green Building rating system. This system rates the greenness of the building by comparing it against some of the nationally accepted benchmarks (Source: www.teriin.org)

In the urban landscape planning arena, the consideration and incorporation of the Smart Cities Concept may also be considered for the sustainable development of the city.

10.4 Policy review

The Jawaharlal Nehru National Urban Renewal Mission has been launched by the Ministry of Urban Development, Government of India in 63 mission states with Guwahati being one of the mission states (Assam Development Perspective, 2011). The premise of this mission is

the need for urban sector development, investment requirement in the urban sector, sustainable infrastructure development, national level reform linked investments and the need for efficiency enhancement.

Various strategies have been undertaken by the Guwahati Development Department to address emerging issues of waste management and public transport in the city of Guwahati. One of the many steps is the Solid Waste Management Project, where the Department has taken steps not only for the scientific disposal of solid waste but also in the use of the garbage as raw materials to produce organic fertilizers and generate electricity. The Integrated Municipal Waste Processing Complex at Boragaon is proposed to include Sanitary Landfill Site, Compost Plant to process organic waste, and a Power Plant of 5MW capacity (Assam Development Perspective, 2011).

The Asian Development Bank has also started the Assam Urban Infrastructure Project and has identified two towns Guwahati and Dibrugarh. The project would be covering water supply, drainage system, solid waste management, sewerage treatment and the development of bus rapid transit system corridors for two cities. The specific sectors identified for Guwahati are water supply, sewerage, transportation and social amenities. The sectors identified for Dibrugarh are drainage, solid waste management and basic services to the poor (The Telegraph, 2010).

10.5 Actions and strategies

The SAPCC actions identified for the thrust area "Urban Planning" and presented in the following table.

	THRUST AREA 6: Urban Planning
	Strategies
Research and technology development	Assess vulnerability hotspots (spatially & temporally) with respect to changes in the climate to identify regions and populations at risk of climate-sensitive diseases in the state
	Mapping changes in vector ecology relative to a changing climate
	Conduct studies to assess links between climate change and malnutrition through changes in nutritional content of crops
	Use remote sensing techniques to assess linkages between climatic variables, vegetation cover and malaria incidence
	Procure and customize health impact models for climate and health impact assessments in the state
	Conduct predictive modeling using high resolution meteorological data (observed and projections) for the region and establish the links with epidemiological parameters
	Develop and maintain a digital health database at fine spatial and temporal scales particularly for mortality and morbidity related to climate sensitive Vector-Borne Diseases, water borne diseases, and those related to higher temperatures and rainfall extremes
Policy measures	Establishment of early warning systems and evacuation plans including emergency preparedness in case of climatic extremes
	Draw synergies with programs such as Integrated Disease Surveillance Project for trend analysis for certain diseases
	Strengthen disaster management plan for the health sector, including management of casualty, mental health, reproductive health, provision of emergency shelter, sanitation, food and water etc.
	Focus on health promotion and lifestyle diseases
Institutions and governance	Improving health data collection, monitoring & surveillance
	Bringing greater convergence amongst programs in the health and non-health sectors to buttress primary, secondary & tertiary health care to help cope with potential climate impacts
	Improve the quality of data, periodicity of collection and the extent of coverage in existing systems of surveillance such as the Integrated Disease Surveillance Program
	Strengthen anticipatory efforts such as vaccination, distribution of mosquito repellants, bed-nets and antibiotics in areas prone to malaria
	NRHM has taken new initiatives as umbrella program to converge all existing program as planned in National level
	Generation of awareness among the rural masses about the water quality issues and the problems related to water borne diseases

Capacity Building	Upgradation of healthcare infrastructure to deal with emergencies during climatic extremes especially in remote districts
	Generation of awareness among the rural masses about the water quality issues and the problems related to water borne diseases
	Promote health education and awareness with respect to climate risks and adaptation through schools and CBOs
	Scientific/Technical training to health sector staff for example, epidemiologists, to carry out research in vulnerability and impact assessments: use of retrospective as well as forecasting/predictive techniques, models and software
	Actions towards robust immunization programs Eg. the second dose of measles vaccine will be included soon in Routine immunization program/ measles immunization drive for all districts of Assam which was piloted in Morigaon district and will be phased out in other districts within current year
	Capacity building by training on disaster management and public health emergency management
	Inter-sectoral co-ordination
	Promotion of awareness level on sanitation measures
	Rain water harvesting structures to use for drinking purposes including recharge structures

Chapter 11: Energy

11.1 Current energy profile and expected trends

The current energy mix based on CEA 2008 values of Assam installed electricity capacity sees the primary energy supply come from gas 59%, hydro 22.4%, steam 13.4%, diesel 4.6% and 0.5 % from renewable sources which includes solar, wind, microhydel and biomass. Thermal power for electricity generation from fossil fuels comes exclusively from natural gas being 1125 GWh (44% of total consumption), which interestingly has one the lowest plant load factors (PLF) in India of 20% when compared to the all-India PLF of 72%[13]. This would suggest a lower level of efficiency within existing thermal power generation capital, highlighting it as an area for significant improvement, or a refocusing of electricity generation towards the other available options.

Other recent trends of note include:

- Amongst the lowest consumers of electricity in India, Assam still has huge power deficit (6.4%)
- Huge transmission & distribution losses (30-40% in 2008-09)
- Sharp rise in power demand (12% every year)
- Access to energy in rural areas for lighting, 24.9% electricity , 74.7% kerosene , 0.2% uses solar energy, 0.1% live without any source of lighting

11.2 Challenges and Issues

a. Detailed GHG quantification and inventorisation plan

As shown in determining the present baseline GHG emissions data, there is no recent data beyond that which was used for the first National Communication in 1995. This data is only at a level of state aggregation and does not have any sectoral analysis. An essential first step and major recommendation in developing the State Action Plan on Climate Change for Assam is to develop and implement a robust plan of routinely measured GHG accounting and inventorisation program which is based on standardized practices. An inventory of GHG estimations for the state of Assam will serve as an important tool to assess key areas where interventions are required and potential policies aimed at the interventions in the context of mitigating GHGs. Further, spatial and sectoral analysis will identify hotspot areas or districts and hence facilitate decision making as to what gases to mitigate, how much mitigation is cost-effective for each gas, where mitigation actions should be located, when to mitigate and how to mitigate. It would also serve as benchmark for comparing the evolution of developmental strategies across regions and sectors.

Further to the GHG estimations, future emissions scenarios for Assam could be predicted using an optimization energy environment modelling framework. This will facilitate in long-

[13] Ibid.

term planning in identifying technological and policy choices today that would result in sustainable low carbon high growth development. This will help avoiding the issue of stranded assets since the technology and investments in many sectors have long life span. However, it may be noted that mitigation beyond the optimum level may require fuel substitution or technology choices that are very expensive and hence an additional burden. Therefore given the developmental goals and priorities of the State, such a modeling framework would facilitate the decision-making at the optimum level. The GHG inventorisation process could also further be extended to indicate levels of local pollutant emissions. This will facilitate understanding of the key areas where impacts of local pollutants are immediate on health for example. Furthermore, there should be integration of a GHG management plan with existing plans and policies targeting relevant sectors such as control of local pollution, energy & infrastructure planning, urban development and industrial development. This plan shall then be consistent with the State's sustainable development and industrial policy.

b. Rural electrification and energy access

Equitable access to energy is a primary developmental challenge for the government of Assam. With over 90% of the population being widely dispersed over rural areas, while the state has made reasonable progress on improving the percentage of villages electrified with 79% of villages as of March 2008 based on 2001 census data, a large percentage of the rural populace (over 80% as of 2004) still do not have access to energy. The percentage of electrification of households in electrified villages is just over 16%, which is the third lowest next to Jharkhand and Bihar, and significantly lower than the all-India average of 43.5%.

Hence GOA has a huge challenge in improving the quality of electricity access while ensuring to do so in a manner that can be low-carbon without compromising on the primary objective of equitable access for all. Particularly given that a large portion of rural villages are considered as remote where convention grid-electrification is deemed not possible, it presents an opportunity to do so through renewable energy alternatives in meeting this objective.

11.3 Climate change perspective: mitigation opportunities

Harnessing renewable energy

The State has already identified the use of renewable energy sources to complement its current shortfall in power generation. This should be augmented to start to replace conventional fossil fuel generation given the seemingly good potential for utilizing renewable energy, particularly hydro, solar and biomass. Brahmaputra basin has a potential of 63,328 MW of hydro power; estimated potential from small hydro in Assam is 117 MW; 89 hydro potential sites identified by the Assam State Electricity Board (CEA, 2001). Hydro power in particular has a large potential with estimations of only 2% of the total north-eastern region's 33 GW being utilized[14]. A Biomass Assessment Study in 13 Blocks of Assam shows a surplus biomass potential of 120025 tones per year with a power generation

[14] Kusre et al, *Assessment of hydropower potential using GIS and hydrological modelling technique in Kopili River basin in Assam (India)*, Applied Energy, 2010.

potential of 12 MW. In addition, AEDA with IITM has put up 30 wind monitoring stations throughout the state to prepare a wind atlas highlighting the potential for wind energy.

Specific areas of focus should include:

- Demonstrate a well designed prototype for renewable energy technology systems for various applications in line with existing AEDA products disseminated (see Table 1.0). This will enable communities to understand the technology and also for policy makers to conduct reliable economic evaluation.
- Launch a comprehensive program for both rural and urban set-ups. Efficient biomass gasification based cooking systems, solar based lighting solutions, solar based irrigation pumps, and mini-hydro.
- Integrated plan for biomass dealing with production, transportation, distribution, regulation, and monitoring. It should look into long term forecasting of demand, proper use of agricultural waste, establishment of awareness generation centers and technical support centers.

Energy efficiency measures in the industrial sector

The industrial sector which includes thermal power is the single largest user of electricity. Assam has some of the lowest PLF in the country and there exists significant scope to employ energy efficiency measures within thermal power and specific industrial sectors. In addition to thermal power, the main industrial sectors that are likely to have a major component of the states GHG emissions, include; cotton and jute textiles, petroleum refining, petroleum products, and to a lesser extent fertilizers and pesticides, cement, pulp and paper, iron and steel and aluminum products.

Mitigation strategies for the industrial sector would include;

- Enhance energy efficiency/process efficiency
- Minimize process emissions
- Switch to low carbon inputs
- Close the carbon loop (recover organic wastes for reuse as feed-stock for energy)

Based on the likely industries, specific reduction opportunities could include;

- Possible super-critical coal and advanced IGCC for new coal base power generation
- Waste heat recovery and improved steam usage optimization
- Optimization of clinker material in cement production
- Flare gas recovery
- Methane avoidance
- Fossil fuel switching
- Specific captive power capability within; cement, chemical, fertilizer, mineral oil & petroleum, mining & quarrying, paper and textiles.

Presently there is no relevant means to regulate the SME sector presenting issues associated with energy and GHG data. In addition, the overall industrial policy or the investment

policy does not consider energy efficiency. Therefore an integrated approach to ensure industrial growth in an efficient manner is needed. Some of the specific action points are discussed in the section below on industries.

Rural electrification through renewable energy

Assam faces some of the largest geographical challenges in providing energy access for its peoples, given its connection to the rest of India through the cyclone and small-scale earthquake prone narrow Siliguri Corridor[15]. Given such areas being prone to natural disasters make connection to the grid and citing of power-lines that would not get destroyed very difficult. The above mentioned rural electrification statistics are not surprising and highlights the imperative for a focus on decentralized renewable energy solutions with which to meet the States electrification needs, but has the added low-carbon imperative associated with it.

AEDA has already identified core areas of renewable energy as mentioned above relating to solar PV, small hydro and biomass gasification. In parallel, these technologies can also help address the rural electrification challenge given their decentralized nature that ability to meet local distribution requirements.

Hydro power in particular has good potential to meet this demand given the priority that the State has placed on this to date (see below in *Policy Review*). For example, the smaller streams in the hilly districts of Karbi Anglong and North Cachar Hills have good potential to harness decentralized power from small hydro power that could assist in the rural electrification requirements. A detailed quantification of the hydro potential still needs to be made and while the Assam State Electricity Board (ASEB) and the Assam Energy Development Agency (AEDA) have conducted preliminary surveys and assessments of hydro potential, such efforts should be emphasized upon given this twin objective.

Transmission

Transmission and distribution (T&D) losses in the state have increased slightly from 34% to 39% from 2006-2007 to 2007-2008 (CEA), being higher than the all-India T&D losses of 27% for 2007-2008. It should be noted that the North Eastern region has the highest regional T&D losses of 43% for the same period. This is likely given the high percentage of low voltage transmission lines in the state. Presently the state has no HVDC transmission lines or any in excess of 220 KV. 95% of the states 79355 km of cables are of low voltage 15/11 KV (32159 km ~ 41%) and lines up to 500 V (42554 km ~ 54%).

Distribution losses should be brought down by taking up improvements which are area specific. All sub stations should be modernized automated and instrumented to improve quality and minimize unaccounted energy losses. There is a need to strengthen the ongoing programs and policies which would not only address the developmental objectives of the state but also climate change mitigation.

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11.4 Policy review

The Department of Power (Electricity), Government of Assam

The Department of Power (Electricity), Government of Assam (DoP) is the central governing department responsible for the States power requirements. To that end there are several policies and initiatives in place that address inclusive access and that are in line with GHG mitigation. Increased capacity has seen the upgrading of older plants. These should and are likely based on higher efficiencies. Similarly, waste heat recovery systems have been commissioned to improve efficiency and boost capacity. The consideration of additional mini and small scale hydro electric power projects is also part of capacity increase plans and should be of a greater focus with respect to increased feasibility studies.

The state has plans to upgrade the transmission network and has secured external funding from the Asian Development Bank as an example. The state has no intention of installing lines in excess of 220 kV and could potentially lose out on opportunities for reduced T&D losses through higher voltages. However efforts are being made at augmentation and up-gradation of transformer capacity as well as improved metering, completed energy auditing processes and computerized customer billing systems, all of which help in increasing efficiency in T&D.

Rural electrification policy is in line with the National Rural Electrification Policy 2004 & Rural Electrification Policy of Govt. of Assam and is implemented through distribution companies. A 2009 target of complete electrification is set, and an updated statement on the current status would assist in determining the existing requirements. Where possible, such rural electrification should be done utilizing renewable energy such as solar. To that end 2145 have been identified as not being able to be electrified through grid connections. Such villages are part of the Ministry of New and Renewable Resource of Energy Programme (MNRE) program of electrification through non-renewable sources. Implementation will be conducted by ASEB, AEDA and the Forest Department.

The Assam Energy Development Agency (AEDA)

Acting as the nodal agency for Ministry of Non-conventional Energy Sources, Govt. of India in the areas of New and Renewable Sources of Energy (NRSE) for the State of Assam, AEDA has the primary objective of coordinating all activities relating to the promotion of renewable energy, specifically for industrial, domestic and rural areas that cannot be connected to the grid.

Existing installations of specific technologies include:

No.	Project/ Programme	Installation so far
1	Solar PV - Village Electrification	105 Villages
2	Solar PV- General Programme	3566 Households
3	Solar Hot Water Systems	15 Locations

4	Microhydel Project	2 Locations
5	Wind Monitoring Mast	3 Locations
6	Energy Park under MNES	11 Locations
7	State Level Energy Park under MNES	1 Locations
8	Energy Park under NEC	1 Locations
9	Solar PV Electrification Project	5 Locations

Table 1.0 – AEDA installations to date (AEDA 2011)

Table 1.0 shows that to date there has been am emphasis solar PV, primarily in domestic initiatives. Given the priority placed on rural electrification and in line with core thrust areas of prioritization, there should be increased focus on this in line with the decentralized local power supply benefits that small scale hydro, solar PV and biomass gasification can play in the regions that are difficult to electrify through conventional grid applications.

Assessments made by ASEB have estimated 93 small hydro sites with a potential of approximately 160 MW. However there appears to be a lack of utilization of this hydro potential with only 2 working units commissioned to date as part of the Karbi Langpi Hydro Power Station with a total capacity of 100 MW(CEA 2010). However, the emphasis of developing this hydro policy is on the radar of the GOA with plans to harness this potential with small hydro power projects across the state to generate 250 MW by 2014. Major issues with implementation of these small hydro facilities derive from the remoteness of the locations and a lack of road infrastructure. Yet such areas hold important biodiversity and ecological significance necessitating that any development policy takes this into consideration.

Involvement in the Clean Development Mechanism (CDM)

As of February 2011, there are three registered CDM projects in Assam with these all relatively smaller scale energy efficiency project within the petrochemical industry;

- NRL -Captive power generation by recovery and utilization of the waste energy (thermal and pressure) of HP steam; 2.7 ktCO2e/yr (1st period)
- NRL -Captive power generation by recovery and utilization of the waste energy (thermal and pressure) of HP steam; 42.0 ktCO2e/yr (1st period)
- Flare Gas Recovery and Utilization of Recovered Flare Gas for thermal requirements in IOCL, Guwahati Refinery; 3.0 ktCO2e/yr (1st period)

There is obviously significant scope to improve upon the scope and level of projects in Assam, particularly in line with the thrust areas of biomass, hydro power and combined heat and power waste heat recovery systems. Raising the necessary capital has been identified as one of the main barrier towards low-carbon technology implementation in the state, greater emphasis on CDM involvement in these identified sectors should be a focus. Specifically the role that biomass and captive power generation projects which have large co-benefits potential in line with existing AEDA implemented projects (such as the Providing 400 Solar Home System in homes of Bodo Tribal Women) would likely garner more favorable CDM consideration.

11.5 Actions and strategies

Recommendations:

- There should be an included mandate within the DoP that deals specifically with efficiency in line with BEE, specifically under the policy and program formulation component.
- An emphasis on having resource identification and quantification of renewable energy potential in the state with respect to solar, hydro and biomass. This will help attract investors and better target resources.
- Am emphasis should be placed on electrification of remote areas with decentralized renewable energy options that do not encroach upon regions of ecological significance (i.e. use of solar PV in lieu of hydro where the infrastructure impacts are greater).
- A renewed focus on CDM projects, which could include focusing on projects with high co-benefits in areas such as biomass, captive power generation, waster recovery and hydro power. This may involved dedicated funding to help identify such projects to be registered as possible programmatic or voluntary carbon units.

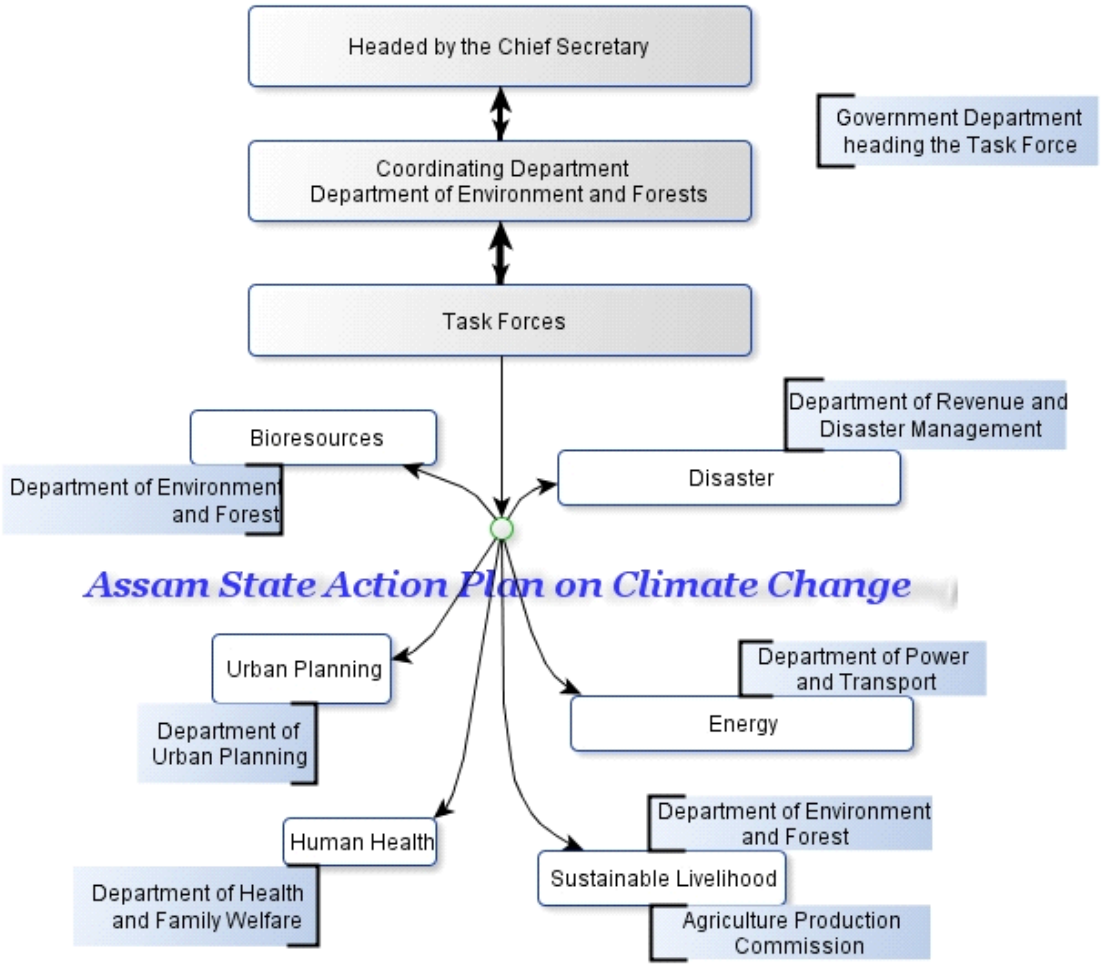
	THRUST AREA 6: Energy
	Strategies
Research and technology development	Sector specific studies to determine the scale of interventions needed to promote efficiency in industrial processes
	Detailed technical assessments to assess the potential of renewable energy applications and identify regions and technologies required
	Assessment of demand side management measures to check the increasing power demand and options to reduce supply side losses
	Energy need/demand assessment in all sectors including agriculture, industry, commercial sector, service and residential sector upto the next 50 years.
Policy measures	Adoption of standards for industrial processes and incentivizing increased uptake of these standards by launching a program for mandatory energy audits in all commercial and industrial facilities
	Incentives and subsidies for uptake of renewable technologies such as solar thermal technology for industrial and commercial heating, water heating in hostels, hotels etc.; solar home lightening systems in rural areas to replace kerosene lamps; solar street lightning; small, micro and mini hydel power plants
	Regulatory mechanisms to reduce both commercial and technical T&D losses
Institutions and governance	Exploring international mechanisms such as CDM, and national mechanisms such as PAT, REC to facilitate policy implementation
	Weighing the option of 'smart industrial clusters'
	Identification of responsibility centers and enabling community level engagements for renewable such as biomass, biogas
Capacity Building	Training of skilled and un-skilled manpower including energy auditors, technician etc to implement the programs and policies
	Awareness generation for Industries and local bodies on the appropriate renewable energy applications and energy efficient processes

PART D IMPLEMENTATION PLAN

Chapter 12 Institutional arrangement

For implementation of the strategies for SAPCC, an efficient and effective institutional framework becomes imperative. Through a consultative process with the concerned government departments a three tier framework has been designed. The framework demonstrates three interactive levels with Task forces at the base and Chief Secretary's Office as the top most authority along with an intermediate Steering Committee that is coordinated by the Department of Environment and Forests, Government of Assam. The Steering committee will comprise of the heads of the respective task forces. Each Task Force would require a clearly defined scope of work and responsibilities. The composition of the Task Forces will be finalized on the basis of such mandates. The Nodal Departments for each Task Force have been tentatively identified and would be subject to further review and necessary approval.

The Organogram presented below gives the schematic of the proposed institutional arrangement:



Chapter 13 Financial Requirement

The Assam SAPCC has identified a wide range of strategies for implementation during the 12 5 year plan period. There are more than 150 action points under the four heads of Research and Technology Development, Policy Measures, Institutional arrangement and governance, and Capacity building. The emphasis is clearly on strategic knowledge generation through promotion of relevant research for the region along with all round capacity building at the institutional as well as individual levels.

The Government of Assam is aware of the huge requirement of investments for implementation of the SAPCC but keeping in view the resources that may be available and development needs of the State, the Government of Assam will need an additional allocation of at least 10% of its total plan size for the implementation of the SAPCC during the period 2012-2017.

Chapter 14 Monitoring and Evaluation

The objective of a monitoring and evaluation (M&E) framework is to measure and asses performance in order to effectively manage outputs and outcomes of the key strategies of each target sector. The focus of the this M&E framework is to assess the implementation process with respect to the targets envisioned, financial resources used and strategies accomplished.

Task forces drawing up monitoring plans for the strategies identified under respective thrust area. Such monitoring plans are expected to identify quantifiable milestones covering both physical and financial targets. This would require an effective reporting system at the level of the departments acting as nodal entities for the task forces and centralized coordination by the Department of Environment and Forests. It is desirable to have regular annual reporting of the implementation of strategies on the basis of performance/process indicators that may serve as the milestones in the implementation timeline.

Reporting and monitoring should be accompanied by periodic evaluation of the impacts of strategies identified and implemented under the SAPCC. Such evaluations should assess the relevance and achievement of objectives, and implementation performance in terms of effectiveness and efficiency, and the nature, distribution and sustainability of impacts.

The design of an appropriate M and E framework for the State of Assam would need to be accompanied by a regular capacity building program for the agencies as well as personnel involved in the related tasks.

PART E ANNEXURES

ANNEXURE I Consultations

1. **Meeting held on 23rd February, 2011**

   Venue: Assam Secretariat, Dispur, Guwahati

The meeting was presided over by the Chief Secretary of Assam Mr N.K. Das and started at 10AM in the Assam Secretariat. The meeting was attended by high level officials of the government agencies along with representation by Regional Meteorological Centre, Borjhar, Guwahati. The meeting started off with a brief introduction of Dr. Arabinda Mishra, Director, TERI by the nodal officer from the GoA for the SAPCC process, Mr. Saraswati Prasad, Prinicipal Secretary, Department of Forestry and Environment.

Dr. Arabinda Mishra, first gave a presentation on the basics of climate change to the gathered audience. There was a comment by Dr. H. Pathak, DDGM, Regional Meteorological Centre, Borjhar, Guwahati, to incorporate studies of weather systems along with climate projections. The second presentation by Dr. Mishra, dealt with specific risks from climate change, vulnerabilities of the Assam state along with the whole North Eastern state and key adaptation needs and also identified $REDD^{+}$ as a mitigation opportunity for the state. There was also a question on as to how much we can say that climate change at present is from anthropogenic drivers and to what extent we can slow process by going totally green. Dr. Mishra responded that currently the anthropogenic causes have surpassed the natural drivers for such a global change and referred to the IPCC scenarios for his second query.

There were questions related to a difference in the climate projections from modeling and the observed data which was reviewed for the presentation. Dr. Mishra cleared the doubt by stating the fact that the observed data was not for the whole state but for a particular climate zone which included a portion of the state. He also brought out the issue of non-linearity in cause and effect and knowledge gaps when it comes to climate system. There was a suggestion by Dr. Satyendra Kumar Choudhury, Director, Assam Science Technology and Environment Council, to run the climate models with the resolution of agro-climatic zones of the state rather than the districts and also to incorporate and design strategies through this plan for facilitating indigenous coping capacities of various tribes of the state to weather variability.

In the end Chief secretary, Mr. Das suggested not to neglect issues of north east region as a whole and suggested to widen the audience in the workshop to be held on March 7-9, 2011. He also suggested incorporating mitigation as a strong point in the SAPCC. There was a concern about the short deadline which is set to be March 25th, 2011 for the draft plan from the nodal officer.

2. **Meeting held on 9th March, 2011**

Venue: Assam Secretariat, Dispur, Guwahati

The Meeting was presided by the Additional Chief Secretary of Assam, Dr. Surajit Mitra and was started at 10 am in the Assam Secretariat. The meeting was attended by high level officials of the government agencies along with representation by Regional Meteorological Centre, Borjhar, Guwahati.

At the outset, the Additional Chief Secretary welcomed all the stakeholders of different divisions who are associated with the preparation of Assam State Action Plan on Climate Change. Mr. Prabir Sengupta, Distinguished Fellow, TERI, said all the stakeholders are free to express their ideas/ comments/ suggestions if any. After the consultation, six major thrust areas were identified and erosion was considered as the major concern for the state. They also pointed out CDM and REDD+ systems as a bit complex to understand.

Overall Suggestions

The Action plan should suggest actions strategies that:

A. Dovetail actions with ongoing plans and policies
B. In line with next five year plans but informed by long term process
C. Is dynamic with no close ended solution; ongoing research

Some focus on impacts of national plans and policies on Assam

Under strategic goals

A. Natural Disasters

i. Consider inclusion of: Landslides, Pattern of wind changes, Soil erosion, Earthquake and some specific strategies for catchments treatment

B. Sustainable livelihood

i. Consider inclusion of livestock, fishery and poultry
ii. Screening of indigenous/ traditional – R&D activity
iii. Importance to checking misuse of biotechnology and bio-piracy
iv. Focus on biodiversity conservation and eco-restoration
v. Inventorisation of indigenous species
vi. Capacity building of JFMC's to create value for NTFPs
vii. Emphasis on research on wildlife conservation/protection given the changes in composition of forest ecosystem

viii. In reference to the subsidies given for Tea garden, similar efforts in the forestry sectors

ix. Creation of private forest

C. Health

i. Livestock health and disease

D. Urban

i. Land use planning

ii. Concept of five smart cities as pilot

In the end, it was decided to send the draft plan on March 25th, 2011 by the Additional Chief Secretary, Assam

3. Meeting held on 25th March, 2011

Venue: Assam Secretariat, Dispur, Guwahati

The meeting was presided over by the Additional Chief Secretary of Assam Dr. Surajit Mitra and started at 10AM in the Assam Secretariat. The meeting was attended by high level officials of the government agencies along with representation by Regional Meteorological Centre, Borjhar, Guwahati. The meeting started off with a brief introduction of all the participants and then Mr. Prabir Sengupta, Distinguished Fellow, TERI gave a brief idea about the purpose of the meeting.

Dr. Arabinda Mishra, Director, TERI, first gave a presentation on the actions & strategies taken for the Assam State Action Plan on Climate Change and feed-back/ comments were welcomed from the other participants.

There were discussions on the Institutional Arrangements for the State Action Plan on Climate Change and strategies were prescribed for each of the thrust areas. There were many valuable updates received from various departments.

The Additional Chief Secretary also provided some suggestions regarding the version, timeframe and implementation plan of the document.

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