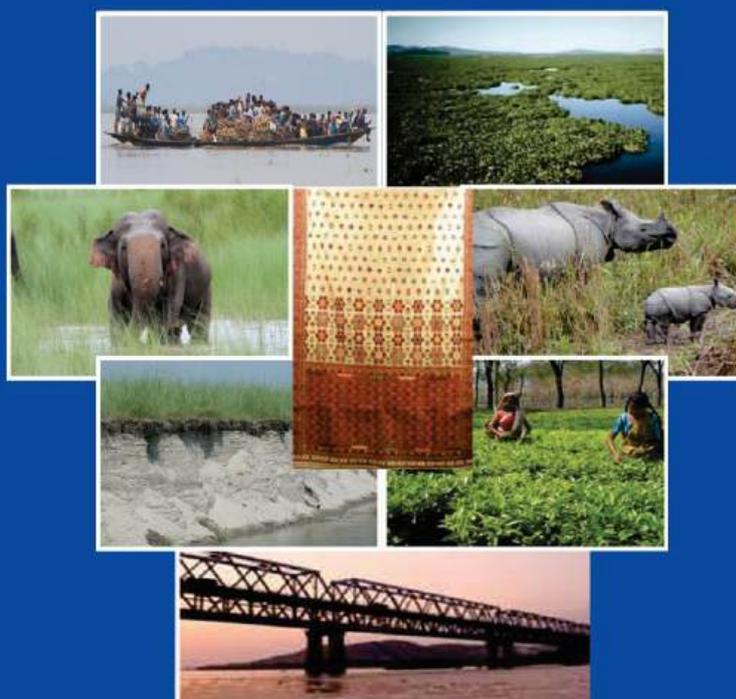


ASSAM STATE ACTION PLAN ON CLIMATE CHANGE (2015-2020)



September, 2015



Department of Environment and Forest
Government of Assam, India

ASSAM STATE ACTION PLAN ON CLIMATE CHANGE (2015-2020)

September, 2015



Department of Environment and Forest
Government of Assam, India

Acknowledgement

The Government of Assam hereby acknowledges the contribution of the Line Departments, Research Institutions, NGOs, Industry associations and individual experts who have contributed towards the development of the content of the Assam SAPCC. It thankfully acknowledges the technical support provided initially by **The Energy Resources Institute** and then by the **Climate Change Innovation Programme** - A Joint Initiative of the Ministry of Environment, Forest & Climate Change, Government of India and United Kingdom -Department for Internal Development (DFID).

Foreword

The world today is faced with the challenge of sustaining economic growth while ensuring environmental conservation. Climate Change is a serious environmental threat to humanity and has implications for sustainable development. Our climate is already changing. Along with continued warming of the atmosphere, erratic rainfall patterns are emerging and as result new patterns of droughts and floods are being observed, which are likely to get more frequent and severe in future given the warming of the earth because of the anthropogenic emissions of greenhouse gases.

The state of Assam has reason to be concerned about Climate Change, as we have a large population dependent on agriculture and forests for livelihood. The state's economy is also dependent on natural resources and any adverse impact on these and allied sectors will negate our efforts to alleviate poverty and ensure sustainable livelihood for the population. This is an opportune time to integrate the concerns of Climate Change into our policies and ensure ultimate objective of sustainable development with inclusive growth.

While engaging with national policies and programmes it is important for us to develop well-researched and formulated mitigation and adaptation strategies specific to the state to respond effectively to the possible impacts of Climate Change. To address the changing climatic conditions State Action Plan on Climate Change (SAPCC) has been developed by the Government of Assam.

The State Action Plan on Climate Change has flagged important issues which require attention. The action plan has highlighted key sectoral concerns and strategies for action in order to lead the way.

The issue of Climate Change is multidisciplinary and demands cross sectoral convergence which requires interdepartmental coordination as well as constructive engagement with all the concerned stakeholders. The Government of Assam would continue to strive to mainstream Climate Change concerns across all the sectors for achieving the objective of sustainable development. Therefore, a special purpose vehicle is being created – the Assam Climate Change Management Society that will facilitate the implementation of the SAPCC.

I appreciate the efforts of various state departments and professionals associated with Climate Change for their commendable work.

Shri V. K. Pipersenia
Chief Secretary, Government of Assam

Preface

Climate change is the greatest global challenge facing us today which through a multitude of impacts poses a risk to our ecology, economy and society. Observation shows that changes being experienced in the climate of Assam are over and above the natural climate variability prevailing in the region. Studies have shown that Assam falls within areas of greatest climate sensitivity, maximum vulnerability and lowest adaptive capacity. Already, water resources in the State are scarce and have a highly uneven distribution both temporally and spatially. A threat such as climate change thus calls for timely and coherent policy response and action that will help reduce vulnerability and build resilience of the State to likely climate impacts.

I am pleased to see that the various departments of the Government of Assam, with the help of a multi-disciplinary team of experts from **Climate Change Innovation Programme - Oxford Policy Management Ltd. (OPML)** have drafted the Assam State Action Plan on Climate Change. The SAPCC has been drafted so as to set up a common but shared agenda for climate change mitigation and adaptation. This State Action Plan is a document which aims to connect between evolving climate science, policies and practices. SAPCC is a dynamic document and would be subjected to periodic review so as to revisit the suggested strategies and constantly refine them.

I hope that the priorities identified under the Climate Change Action Plan will lead to sound implementation of strategies that will help to address the challenge of climate change in the State and ensure a future of sustainable development.

Shri Davinder Kumar
Additional Chief Secretary
(Department of Environment and Forests, Government of Assam)

Table of Contents

Executive Summary	9
Setting the Context.....	9
Strategies to combat climate change in Assam	9
Way Forward	30
List of Figures.....	34
List of Tables	35
Abbreviations.....	36
SECTION A: INTRODUCTION, STATE PROFILE AND VULNERABILITY DUE TO CLIMATE CHANGE.....	39
1. Background	40
2. Principles.....	41
3. Process of Preparation of SAPCC	41
4. State Profile	44
4.1 Geophysical Situation	44
4.2 Natural Resources.....	44
4.3 Demographic Profile and its Spread	45
4.4 Economic Profile	46
4.5 Physical and Social Infrastructure.....	47
5. Observed Changes in Climate and Projections	48
5.1 Observed weather and Climate trends.....	48
5.2 Climate Projections.....	51
6. Vulnerability of the State	52
6.1 Physical Vulnerability.....	52
6.2 Anticipated Economic Vulnerability.....	55
SECTION B: ADAPTING TO CLIMATE CHANGE	57
7. Water Resources.....	58
7.1 Water availability.....	58
7.2 Managing Floods.....	60
8. Agriculture	63
8.1 Crops.....	64
8.2 Horticulture	69
8.3 Assam Tea.....	71
8.4 Animal Husbandry and Dairying	73
8.5 Fisheries	78
9. Forests and Biodiversity.....	82

8. Habitats.....	89
8.1 Water Supply	90
8.2 Municipal Waste Management and Sewage treatment in cities.....	94
8.3 Road Transport	96
8.4. Inland Water Transport	98
8.5 Human Health	99
8.6 Managing Urban Space	102
9. Energy	103
9.1 Access to Electricity	103
9.2 Energy Efficiency.....	107
SECTION C: WAY FORWARD	109
10. Implementing SAPCC and Knowledge Management.....	110
10.1 Implementing SAPCC	110
10.2 Knowledge Management.....	112
11. Integrating Climate Change finance in adaptation Planning	114
Annexure 1	115
Annexure 2	120

Executive Summary

Setting the Context

Given the unique physiography, climate and location of Assam in the North Eastern Himalayas with mighty Brahmaputra flowing through, the State is endowed with ample water resources and rich floral and faunal biodiversity. As a result, 86% of its population thrives on agriculture and forest produce. Changing course of Brahmaputra and recurrent floods have led to widespread damages, but people residing in these regions have adapted to such hazards using indigenous approaches developed since ages.

Discernable changes in these systems are now emerging due to changes in climate, impacting the economy associated with these resources. Observations indicate that since the last 60 years (1951-2010), the annual mean temperature in Assam has increased by 0.59°C and the annual rainfall has decreased by -2.96/mm per year. Frequent, heavy precipitation in the form of cloud bursts have been reported in recent years which have led to devastating flash floods. Climate change projections for Assam indicate that mean average temperature is likely to rise by +1.7-2.2°C by mid-century with respect to 1971-2000. There is likely to be increase in extreme rain fall events by +5 to 38%. All across the State, except in the southern districts, droughts weeks are going to rise as well, by more than 75% with respect to the base line (1971-2000). As regards floods, projections increase a rise in events by more than 25%.

It is essential that adaptation plans to combat the impacts of climate change are factored in the development process now to avoid economic burden of adaptation in the long run, and gain from new opportunities that will be thrown up along the way.

The following sections describe briefly the challenges and corresponding adaptation strategies.

Strategies to combat climate change in Assam

Water resources: Currently, the overall resource seems adequate, but water stress conditions in many parts of the State is common during lean flows in the rivers. Increasing incidences of extreme rainfall in the hilly areas are leading to high run-offs affecting ground water recharge. For sustainability of water resources and ensuring that sectoral demands are met with in the future, the proposed adaptations strategies are focusing on institutional reforms, water use efficiency in different sectors, water resource augmentation, and diversified livelihoods.

Sl. no.	Strategy – Water Resources; responsibility: Department of Water resources,	Responsible Agency and time period	Cost (INR Cr)	Priority
1	Undertake assessments to ascertain the institutional reforms required to address water generation, distribution, and use issues in a climate change context	Deptt of Water Resources PHE Irrigation	0.50	VH
2	Set Up Assam State Water Resource Council	Deptt of Water Resources	-	H

Sl. no.	Strategy – Water Resources; responsibility: Department of Water resources,	Responsible Agency and time period	Cost (INR Cr)	Priority
3	Assess water use efficiency potential in Agriculture at one location with respect to base line and replicate in later years using the following technologies <ul style="list-style-type: none"> - Reuse of waste water (1000 ha) - Water efficient crops (1000 ha) - SRI or multiple aeration for rice cultivation (1000 ha) 	Deptt of Agriculture	1.00 0.50 0.30	VH
4	Promote conjunctive use of surface and ground water at a pilot scale covering 1000 ha to improve water use efficiency	Deptt of Water Resources	2.00	VH
5	Promote water use efficiency in industry <ul style="list-style-type: none"> - Explore possibility of water markets - Through reuse of waste water 	Deptt of Industry	0.50	VH
6	Encourage use of recycled water from domestic waste water in urban areas (2 wards in one city)	ULBs	1.00	VH
7	Undertake continuous awareness raising campaigns on water conservation through media	PHE/ULBs	0.10	H
8	Enable spring shed development in hilly areas to restore the perennial streams within forests	Deptt of Water Resources	3.50	VH
9	Promote backyard fisheries in small tanks in same area where water use efficiency will be piloted in agriculture	Deptt of Fisheries	1.00	VH
	TOTAL		10.40	

Floods and Erosion: Given the fact that substantial increase in extreme precipitation events are expected in the future, managing erosion and impacts of flooding events will be a major challenge that the State will have to combat annually. The strategies envisaged are as follows.

Sl.No.	Strategy – Floods	Responsible Agency and time period	Cost (INR Cr)	Priority
1	Detailed scientific study to understand the nature of river flow and its impact on erosion to control erosion in the state of Assam and enable land reclamation	WRD	0.50	VH
2	Undertaking study to assess intensity and recurrence frequency of floods due to climate change and extent and depth of	WRD	2.8 (@ 0.2 Cr per city)	VH

	flooding in 14 major Urban agglomerates in the 14 districts prone to floods			
3	Develop an integrated flood, erosion and sediment management Action Plan for the Brahmaputra basin in 3 major regions in Assam, namely, for Upper, Middle and Lower Assam and drawing upon knowledge on improved technical standards, global best practices and technologies	WRD Partners: ASDMA, NESAC, IMD, Research Instt, NGOs	1500.00	VH
4	Extending River Bank Stabilization work using geotextile material for river bank training all along the Brahmaputra and Barak river banks.	WRD	750.00	VH
5	Setting up a North East Hydrology Data Management Centre through basin management approach for managing flash floods.	WRD	2.00	VH
6	Documenting possible indigenous community based and new adaptation strategies for adapting to floods and implementing the same at pilot scale along with development of fiscal measures for averting climate induced risks.	WRD	5.00	VH
7	Construction of multipurpose flood shelter with inmate capacity of 500 people / unit in Dhemaji, Lakhimpur, Barpeta; Morigaon & Majuli in Jorhat.	ASDMA	14.00	H
8	Develop district level management plans to deal with multiple hazards including floods in a changing climate context	ASDMA	8.10	H
9	Strengthen Infrastructure and Community based flood early warning system	ASDMA	8.00	
	TOTAL		2282.40	

Agriculture, Horticulture, Tea and Fisheries: Warming of the temperature reduces production of staple crops such as rice, horticulture produce, economically important tea produce, milk yields and fish catch. Coupled with increasing intensity of rain fall in some areas and intensive droughts in others, emergence of new pests and diseases, the yield realization in a business as usual agriculture practice scenario are likely to become lower. Following are some strategies identified to make agriculture, horticulture and fisheries sustainable to the extent possible in a changing climate scenario.

Sl No.	Strategy- Crops;	Responsible Agency	Budget (INR Cr)	Priority
1	Strategy 1: Development district wise climate smart adaptation action plans			
1.1	Assessing District wise exposure and vulnerability of agriculture systems to climate variability and change and developing climate smart Adaptation Strategies through Stakeholder consultation for all 27 districts taking into consideration the agro-climatic zone in which they are located	DoA	6.75	VH
	Total Strategy 1		6.75	
2	Strategy 2: Develop, disseminate, and practice climate smart packages at Pilot scale. Coverage: 90,000 ha	DoA		
2.1	Preparation of DPR through PRA to record phenological variances in crops/plants, soil types, soil and water conditions, new pest host relationships	DoA	0.05	
2.2	Application of climate smart agronomic practices to retain optimum production	DoA	0.15	
2.3	Assessing and broadcasting knowledge on appropriate seed rate, soil moisture conservation activities, water efficient technologies including drip irrigation and tillage operations	DoA	0.10	
2.4	Redefining cropping pattern suitable for each agro-climatic zone	DoA	0.10	
2.5	Establishing demonstrative integrated farming systems by introducing agro-forestry and agro-pastoral practices	DoA	5.00	
2.6	Restore natural water bodies to conserve run off.	DoA	40.00	
2.7	Community vermi-composting	DoA	5.00	
2.8	Expansion of area under low water requirement crops	DoA	5.00	
2.9	Integrated disease management practices	DoA	5.00	
2.10	Develop and propagate crop specific weather indexed crop insurance	DoA	30.00	
2.11	Train farmers on disaster risk reduction techniques	ASDMA and DoA	0.50	
	Total (Strategy 2):		90.90	
3	Research			
3.1	Developing water and temperature stress tolerant varieties with focus on integrating C4 characteristics in C3 Rice to make photosynthesis efficient at higher temperatures and hence make rice plants temperature and water stress resilient	DoA	0.05	
	Total Strategy 3:	DoA	0.50	
4	Knowledge management, training and skill development	DoA	5.00	

4.1	Automatic weather stations (8 in number) at block level	DoA	17.52	
4.2	Sustainable eco-friendly horticulture in hilly areas	DoA	12.50	
4.3	Computerised weather recording and synthesizing centre	DoA	0.08	
4.4	Establishment of Climate Change Agriculture research Centre	DoA	0.10	
4.5	Training of department functionaries on CC adaptation for developing climate resilient agriculture	DoA	0.10	
4.6	Training of farmers on climate smart packages of practices	DoA	0.15	
4.7	Documenting indigenous knowledge on adaptation for integration with modern techniques	DoA	0.005	
4.8	Publication and dissemination of success stories	DoA	0.005	
4.9	Workshops/seminars on CC resilient agriculture system development	DoA	0.10	
	Total Strategy 4:		35.56	
5.0	Strengthen accessibility to markets			
5.1	Establish market intelligence cell	DoA	1.00	
5.2	Skill development towards producing beneficiated food products (cover 14 districts in Phase 1)	DoA	14.00	
5.3	Establish farmers' companies (village cluster approach in 14 districts)	NABARD	28.00	
5.4	Strengthen cold storage networks (14 districts)	NABARD	14.00	
	Total Strategy 5		57.00	
6	Strategy 6: Protect irrigation schemes from siltation due to soil erosion			
6.1	Plant plantation trees every 25 m on both sides of irrigation canals and reservoirs and beside inspection roads- cover 19244 km	Department Of Irrigation	124.48	
6.2	Install 10 HP pumpsets in irrigation scheme to offset emission from fuel combustion in motors (10 numbers)	Department Of Irrigation	4.00	
	TOTAL AGRICULTURE CROPS		318.74	

Sl.No	Strategy- Horticulture;	Responsible Agency	Budget (INR Cr)	Priority
1	For sustainable incomes in hilly areas promote plantation crops like cashew nut- Focus: Jhum areas and others. Coverage: 2500 ha.	Directorate of Horticulture Assam	12.50	VH

2	Popularize indigenous thermal and water stress resistant varieties – black Jamun (<i>Polnia</i>), Sapida (<i>Leteku</i>), Jackfruit, Hog plum (<i>Amara</i>) etc. Coverage: 1000 ha,	-do-	2.50	H
3	Facilitate off season availability of vegetables by promoting protected environment production practices	-do-	4.00	H
4	Promote water use efficiency through water harvesting, drip and sprinkler irrigation: Coverage: 500 ha.	-do-	10.05	VH
5	Ensure soil health – propagate integrated nutrient management in hilly areas prone to soil erosion: Coverage: 2500 ha.	-do-	1.0	H
6	Manage emerging pests and disease - through Integrated pests and disease management practices. Coverage: 2500 ha, District	-do-	1.0	VH
7	Develop disease prevalence maps and track the same across the years in the entire State Developing disease forecasting and dissemination systems for farmers through SMS and other media	-do-	0.05	VH
8	Undertake soil and water conservation in micro watersheds in hilly Jhum areas: 16 thousand ha	Department of Soil and Water Conservation	21733	VH
9	Develop and propagate weather indexed crop insurance	Department of Soil and Water Conservation with insurance agency	0.50	VH
10	Undertake training of farmers on packages of practices towards climate change adaptation and	ASDMA with Directorate of Horticulture	1.00	H

	disaster risk reduction in different agro-climatic zones			
	TOTAL		21766.57	

Sl.No.	Strategy- Tea	Responsible Agency	Budget (INR Cr)	Priority
1	Real time remote sensing based soil moisture mapping to help in crop planning along with validation at field level; Coverage: All Tea growing areas	Tea Board	5.00	VH
2	Assess soil carbon across all tea Stations.	Tea Board	5.00	VH
3	Identify, procure and broadcast production of thermal and water stress resistant tea varieties,	Tea Board	10.00	VH
4	Disseminate and support adoption of water use efficient technologies – sprinkler and drop irrigation. Coverage-	Tea Board	10.00	VH

	1/4 th of area under small holders in the present plan			
5	Support development of water harvesting structures for small holders to abate water stress conditions	Tea Board		VH
6	Develop pest and disease forecasting systems for tea related pests and planters and develop dissemination strategies	Tea Board	0.50	VH
	TOTAL		30.50	

Sl.No.	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority
1	Grading up of local cattle and buffalo stock with suitable thermal resistant high milk yielding Indian indigenous varieties such as Murrah / Sahiwal through Artificial Insemination- Cover at least 13 districts Assam, including remote districts	Animal Husbandry	10.00	VH
2	Undertake Anoestrus management in	Animal Husbandry	10.00	VH

Sl.No.	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority
	buffalos simultaneously in the above chosen districts			
3	Create gene bank for conservation of threatened breeds (Five)	Animal Husbandry	5.00	
4	Establish community based cattle shelters with designs that enable sustenance of conducive micro climate for livestock to survive in extreme heat conditions in 219 blocks to accommodate at least 300 cattle and buffalo of small and marginal farmers.	Animal Husbandry	21.90	VH
5	Harness energy from dung collected at these community centres - produce 1000 cu m of biogas one in each 219 blocks	Animal Husbandry	219.00	H
4	Undertake fodder cultivation using hydroponic technique - in the shelters in 219 blocks	Animal Husbandry	10.95	VH
5	Develop and propagate Weather indexed insurance for loss in milk yield due to heat stress. Coverage: All crossbred and	Animal Husbandry	5.00	VH

Sl.No.	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority
	genetically upgraded indigenous cattle and buffalo in 219 blocks			
6	Develop Disease diagnostic- disease forecasting system	Animal Husbandry	1.00	VH
7	Disease Management – vaccination, fumigation etc.	Animal Husbandry	233.68	VH
8	Disease diagnostic (DDL) (Contractual Doctor, TA and other recurring expenses) in 26 districts	Animal Husbandry	78.00	H
9	Training / capacity building of technical and non-technical person on adaptation to climate change and relevant technologies - 219 blocks	Animal Husbandry	21.90	VH
10	Establish infrastructure for safe, quick and effective transfer of milk from producer to chilling plants in all 27 districts	Dairy Development	144.20	VH
11	Establish new and refurbish existing Milk Collection Centers with required technical	Dairy Development	47.70	VH

Sl.No.	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority
	infrastructure in all 27 districts			
12	Set up of chilling plants to stop bacterial growth at higher temperatures in all 27 districts	Dairy Development	114.80	VH
13	Capacity Building of Dairy farmers in all 27 districts on <ul style="list-style-type: none"> Scientific management of indigenous dairy cow for higher milk production Improved milk hygiene and quality Practices of quality milk production technologies in the changing climate scenario 	Dairy Development	31.78	VH
14	Develop and disseminate package of practices amongst farmers for mitigating disaster risk reduction such as during floods and droughts (in all 27 districts)	Animal husbandry and dairy development	27.00	VH
	TOTAL		10421.10	

Sl.No.	Strategy – Fisheries	Responsible Department	Budget (INR Cr)	Priority
1	Creation of up-to-date state level GIS based database on water and	Department of Fisheries	10.00	VH

Sl.No.	Strategy – Fisheries	Responsible Department	Budget (INR Cr)	Priority
	fish type & fishery resources; water resources and their potential users			
2	Restoration of natural fish breeding and feeding grounds	Department of Fisheries	200.10	VH
3	Productivity enhancement and utilization of potential area	Department of Fisheries	80.00	H
4	Avail Quality fish seeds	Department of Fisheries	6.90	H
4	Conserve indigenous fish species	Department of Fisheries	4.90	H
5	Reclaim ponds and beels wherever possible (5000 ha)	Department of Fisheries	50.00	H
6	Promote rain water harvesting based small tank fisheries in hilly areas (5000 HH)	Department of Fisheries	25.00	H
7	Develop packages of practices for fishermen to sustain their production in an climate change context	Department of Fisheries	2.00	VH
9	Develop and disseminate weather indexed insurance for fisheries sector- to benefit small and marginal farmers and link it to disaster risk reduction	Deptt of Fisheries. ASDMA, Insurance agency	0.50	VH
10	Undertake capacity building within communities to	Department of Fisheries	0.60	VH

Sl.No.	Strategy – Fisheries	Responsible Department	Budget (INR Cr)	Priority
	encourage them to embrace State of the Art package of practices for fisheries			
11	Establish block level kiosks for fishery related information dissemination including SMS	Department of Fisheries	10.05	VH
12	Research	Department of Fisheries	1.77	VH
	TOTAL		393.82	

Forest and Biodiversity: Forests essentially play a key role in providing different ecosystem services that include its role in conditioning the microclimate in and around forests, conservation of watersheds originating from within forests, and providing timber and biodiverse NTFPs that are harvested to sustain livelihoods of forest dependent communities. In Assam, forests are increasingly getting degraded due to population pressure and associated drivers. Further, climate change is influencing the biodiversity, thus affecting forest produce and hence dependent livelihoods. The State is also endowed with extensive biodiversity rich wetlands that are increasingly being threatened by anthropogenic drivers and climate change Strategies identified to combat the impacts of climate change are as follows.

Sl. No.	Strategies – Forest and Biodiversity		Costs (INR CR)	Priority
1	Reduce degradation of forests through Secured Assisted Natural Regeneration	Forest Deptt	70.00	VH
2	Improve density of cover in degraded forest areas	Forest Deptt	182.00	M
3	Implement safeguards against encroachment in RFs and Pas	Forest Deptt	467.00	VH
4	Build climate resilience of forest based livelihoods	Forest Deptt	321.00	VH

Sl. No.	Strategies – Forest and Biodiversity		Costs (INR CR)	Priority
5	Promote alternate sources of energy for wood substitution as fuel-energy plantation, solar plants, biogas, LPG	Forest Deptt	15.5	H
7	Improve resilience of wild life-through secured wild life corridors and provide compensation to communities	Forest Deptt	125.00	VH
8	Procure crucial areas surrounding Protected Areas for extended protection to threatened and endangered species (e.g. various additions to the Kaziranga NP)	Forest Deptt	600.00	VH
9	Improve Protected Area Management – control invasive species; enrichment planting, micro-ecosystem improvement	Forest Deptt	15.00	VH
10	Undertake intensive management of Wetlands for biodiversity conservation, ground water recharge, eco-tourism	Biodeiversity Board	7.00	H
11	Create Gene Banks for threatened indigenous biodiverse species (Ex-situ) - 2 central facilities and 35 site banks	Bodiversity Board	11.50	M
12	Strengthen activities of Assam biodiversity Board and undertake awareness generation	Biodiversity Board	9.00	H
13	Plan for conserving biodiversity in a changing climate scenario	Biodiversity Board	35.05	VH
14	Improving Tree cover outside Forest areas: Avenue, city forests, Panchayat Forests, Homestead, Gardens, Parks, Institutional lands etc	Forest Deptt	100	H
15	Undertake systematic plantation on special / difficult sites- <i>Jhum</i> lands for soil conservation and in <i>Char</i> areas (river islands) for preventing erosion of banks during heavy floods	Forest deptt	25.00	VH
16	Protect against Forest Fires specially in Hill areas - Create Central Monitoring Unit/Field (2 central units) and Stations/Field gears (20 field stations)	Forest Deptt	20	VH

Sl. No.	Strategies – Forest and Biodiversity		Costs (INR CR)	Priority
17	Integrate criteria and indicators of Sustainable Forest Management in a changing climate context into Working Plans	Forest deptt	6	VH
18	Commission preservation Plots: studies into change in vegetation is response to CC – genetic resource preservation	Forest deptt	5	H
19	Pilot Studies on Carbon stocking in forests: establish the protocol for measuring, reporting and verification systems for forest carbon.	Forest deptt	10	H
20	Vulnerability Study of Forest Ecology to Climate Change including assessment of changes in Forest Types / sub-types	Forest deptt	100	H
21	Undertake policy review and develop Policies to address gaps in the State Forest Policy, Bamboo & Cane Policy, Wetland Policy, Eco-tourism Policy in the changing climate context	Forest deptt	5	VH
22	Link Micro-plans with Working Plans	Forest deptt	5	H
23	Reduce carbon footprints of forestry infrastructure- Eco-friendly buildings/gadgets etc; 800	Forest deptt	960	H
24	Develop a Manual for disaster risk reduction for averting landslides in forests, for averting forest fires and for avoiding mortality of wildlife during floods	Forest deptt & ASDMA	0.50	VH
	TOTAL		19826.50	

Habitats: As the population is rising in urban areas, and the changing climate is causing higher temperatures in cities, flash floods due to extreme rains amongst others, multiple challenges related to the following are compounding

- solid waste management,
- sewerage disposal,
- drinking water availability,
- adequate transportation and
- Managing Human Health

The strategies to combat the above are as follows.

S.No	Strategies- Potable Water availability in cities	Department Responsible	Costs (INR CR)	Priority
1	Ensure water availability in a changing climate scenario			
	Roof top rain water harvesting; 2500 numbers (in southern Assam cities)	PHE	53.75	H
	Check dam, 30 numbers (in Southern Assam cities)	PHE	3.00	M
	Pond HRF (horizontal roughing Filter-Geo membrane line masonry); 50 numbers	PHE	0.75	M
2	Ensure potable water during floods			
	Board mounted WTP (water treatment plants) for flood effected areas; 5 numbers	PHE	5.00	M
	Speed boat for distribution of WATSAN material during climate change induced floods	PHE	2.50	M
3	Facilitate ground water recharge even in extreme rainfall condition			
	Artificial recharge with pit/trench; 4000 numbers	PHE	40.00	VH
4.	Enhance water use efficiency			
	Metering of water supply connections in at least 13 major cities- to cover at least 5 cities in 5 years	PHE	100.00	VH
5	Increase solar energy penetration and reducing load on conventional source			
	Solar pumping in PWSS; 2000 numbers	PHE	200.00	VH
	Solar lighting in Head office	PHE	4.25	H
6	Research			H
	Assess risk due to climate change and designing required Infrastructure and System Operation for water supply systems in one key city in Assam	PHE	1.00	VH
7	Capacity building			
	Develop capacity of government officials towards assessing the vulnerability of water resources in their districts and drafting strategies for ensuring water availability (for all 27 districts) and disaster risk reduction	PHE and ASDMA	1.00	VH
	Undertake Training and skill development of Govt. functionaries on climate change resilient WATSAN system	PHE	0.30	H
	Exposure visit of Govt. functionaries on climate change resilient WATSAN system	PHE	0.50	H
	TOTAL		412.05	

S.No	Strategies	Department Responsible	Costs (INR CR)	Priority
1	Wastewater treatment			
	Community Waste Management System in peri-urban areas (approx. 4 nos in each block)-1000 in number	PHE	0.20	
	Trailer mounted community Bio-toilet for areas affected with climate change resulted flood- 45 in number	PHE	0.32	
	Colony based sewage treatment plants- recycled waste water will be used for parks, gardens and other uses in all cities (at least cover 2 cities in 1 st 5 years)- 60 in number	Department Responsible	2.00	
2	Solid waste management	Department of Transport		
	Feasibility studies in 14 major cities in Assam, excluding Guwahati for setting up integrated waste management plants	Department of Transport	1.00	
	Feasibility study to set up cluster based MSW management amongst class II and III tier cities in Assam	Department of Transport	2.00	
	Undertake -MSW management -de-silting of drains -sewage treatment In flood prone cities in Assam spread along 14 districts along the banks of Brahmaputra. Cover 2 cities in the 1 st 5 yrs	Department of Transport	720.00	
	TOTAL		725.00	

S.No	Strategies- Road Transport	Department Responsible	Cost (INR Cr)	Priority
1	Installation of CNG pump stations across major cities of Assam; 100 depots	Department of Transport	25.00	VH
2	Procurement of CNG enable buses, 1000 buses	Department of Transport	250.00	VH
3	Assess requirement of non-motorized transport numbers and Introduce tracks for non-motorized transport along existing roads, 10 major cities	Department of Transport	2.00	H
4	Retrofitting all Public Vehicles with CNG Kit – Policy regulations to be formulated	Department of Transport	100.00	VH

5	Introducing intelligent traffic management systems, 10 major cities	Department of Transport	10.00	H
6	Construct parking slots in Guwahati, Tinsukia, Dibrugarh, Nagaon, Tezpur, Jorhat and Silchar. Partial cost of construction, 7 major cities	Department of Transport	35.00	H
7	Promote better driving practices and maintenance of vehicles among truck, bus and car drivers to enhance fuel efficiency	Department of Transport	1.00	H
8	Study on BRT for 7 major cities other than Guwahati where BRT is already planned	Department of Transport	0.50	H
9	Vulnerability assessment study of transport system of Guwahati and other important cities due to climate change	Department of Transport	0.50	VH
10	Developing manual for building climate resilient roads and bridges and train engineers on retrofitting old ones and new designs (all Districts)	Department of Urban Development	14.00	VH
TOTAL			438.00	

Sl. no	Strategies- Inland Water Transport	Department Responsible	Costs (INR Cr)	Priority
1.	The IWT vessels rely on fuel oils for most powering needs, but tighter emission regulations and the need to 'go green' and hence conversion of existing Diesel Marine Engines to CNG driven engines proposed. (40 engines in 20 vehicles)	Inland Water Transport Department	10.00	H
2.	Solar powered passenger vessel in 10 vehicles	Inland Water Transport Department	100.00	H
3	CNG Filling Station (Phase: I – Guwahati-02) (Phase: II- all over Assam-04)	Inland Water Transport Department	10.00 10.00	H M
4	Conversion of existing engines of IWT Vessels to CNG, 40 vessels	Inland Water Transport Department	10.00	M
TOTAL			140.00	

Sl. no	Strategies- Urban Health	Department Responsible	Costs (INR Cr)	Priority
1	Developing disease forecasting system for disease outbreaks on a daily basis in consonance with daily weather forecast	Deptt of Health and Family Welfare	1.00	VH
2	Develop mobile based apps on disease outbreak forecast and prevention measures – a to do list	Deptt of Health and Family Welfare	1.00	VH
3	Study and map new and emerging diseases in consonance with CC projections	Deptt of Health and	1.00	VH

		Family Welfare		
4	Extending IDS to urban areas and to private clinics	Deptt of Health and Family Welfare	10.00	VH
5	Including heat wave incidences under IDSP in Assam	Deptt of Health and Family Welfare	10.00	VH
6	Conduct studies to assess links between climate change and possible malnutrition in the State especially amongst children	Deptt of Health and Family Welfare	1.00	VH
7	Review and retrofit disaster risk response strategies of the department in view of climate change using CSDRM tool	Deptt of Health and Family Welfare	0.25	VH
7	TOTAL		24.00	

Sl. no	Strategy-Managing Urban Spaces	Department Responsible	Costs (INR Cr)	Priority
1	Reevaluate drainage system of the urban space/city and realign it with the maximum expected volume water that will be received due to extreme rainfall and avenues and outlets required for dissipation. Pilot: 7 cities	JNNURM	3.50	VH
2	Map and Evaluate the landslide prone areas in a hill city and devise and implement adaptation strategies to bind the soil and prevent soil erosion and hence landslides - engineering as well as vegetative measures (take 3 hill cities)	JNNURM	15.00	VH
3.	To dissipate heat in open areas built up due to heat island effect design landscapes dotted with greens that can cool the micro climate (focus on 3 cities that have very high temperatures in summers w.r.t. other cities in Assam)	JNNURM	15.00	VH
4	Strengthen disaster response of ULBs through Capacity Building (Cover: Guwahati, Silchar & Dibrugarh and 10 Towns viz. Tinsukia, Sivasagar, Jorhat, Tezpur, Bongaigaon, Nalbari, Nagaon, Mangaldoi , Dhubri & Kokrajhar)	ASDMA	6.5	
5	Training and capacity building of Community, NGOs, CBOs and Govt. Officials, educators, students on Disaster Risk Reduction and Climate Change Adaptation	JNNURM		
	TOTAL		40.00	

Energy: Energy generation capacity is not enough to meet the demand in the State, especially in remote areas. The demand is likely to go up as temperature continues to rise. Renewable energy as an additional source is being promoted in the State for

disaggregated generation of electricity. Additionally, energy efficiency in conventionally produced fossil fuel based energy is another area where large potential of energy saving exists, thus reducing existing levels of associated GHG emissions. The strategies suggested by the State to achieve the above mentioned objectives are as follows.

Sr. No	Strategies- Energy Capacity Addition	Implementing Agency	Costs INR in CR	Priority
1	Setting up of 60 MW SPV Power Plant at Amguri, Assam	APDCL	491.84	H
2	Setting up of 2 MW SPV Power Plant at Namrup,	APDCL	18.25	VH
3	Setting up of 2 MW SPV Power Plant at Lakwa,	APDCL	18.25	VH
4	Capacity Building in APDCL	APDCL	0.15	H
5	Protection of Erosion of river bank for water intake pump at Desang river for Lakwa TPS	APDCL	0.98	VH
6	Master drain system of Lakwa Thermal Ppower Station with Effluent Treatment Plant	APDCL	0.24	VH
7	Crude oil drain pit development for gas intake station at Lakwa TPS & accumulator tank for Gas compressor lubrication drain	APDCL	0.04	VH
8	Lower Kopili Hydroelectric Project (120 MW), Dima Hasao and Karbi Anglong Districts, Assam	APDCL	0.28	VH
9	Development of Small Hydro Electric Projects	APDCL	0.60	H
10	Switchyard illumination at Namrup TPS-LED	APDCL	0.20	H
11	Street lighting at Namrup TPS- LED	APDCL	0.20	H
12	Additional thermal Insulation on GT Unit #1, #2, #3 & #4 at Namrup TPS	APDCL	0.14	H
13	Anti-erosion measure at Dillighat Intake of Namrup TPS	APDCL	1.0	VH
14	Renovation / Repairing of cooling system of Steam Turbine unit-5, splash bar changing at Namrup TPS	APDCL	1.00	VH
15	Research and Development	APDCL	0.75	H
	SUB TOTAL- APDCL		533.92	
16	Development of State Renewable Energy Policy	AEDA	0.25	
17	Installation & Promotion of 25 MW aggregate capacity of Grid Connected Solar Power Plant at different vacant land of APDCL with capacity ranging from 1 MW to 5 MW	AEDA	15.30	VH
18	Installation of Grid Interactive Rooftop/Ground mounted Solar Power Plant (with battery backup) at important Govt. Building of Assam with capacity ranging from 5 kW to 50 kW	AEDA	73.89	VH
19	Illumination of important towns/historical locations of Assam through Solar Street	AEDA	22.50	VH

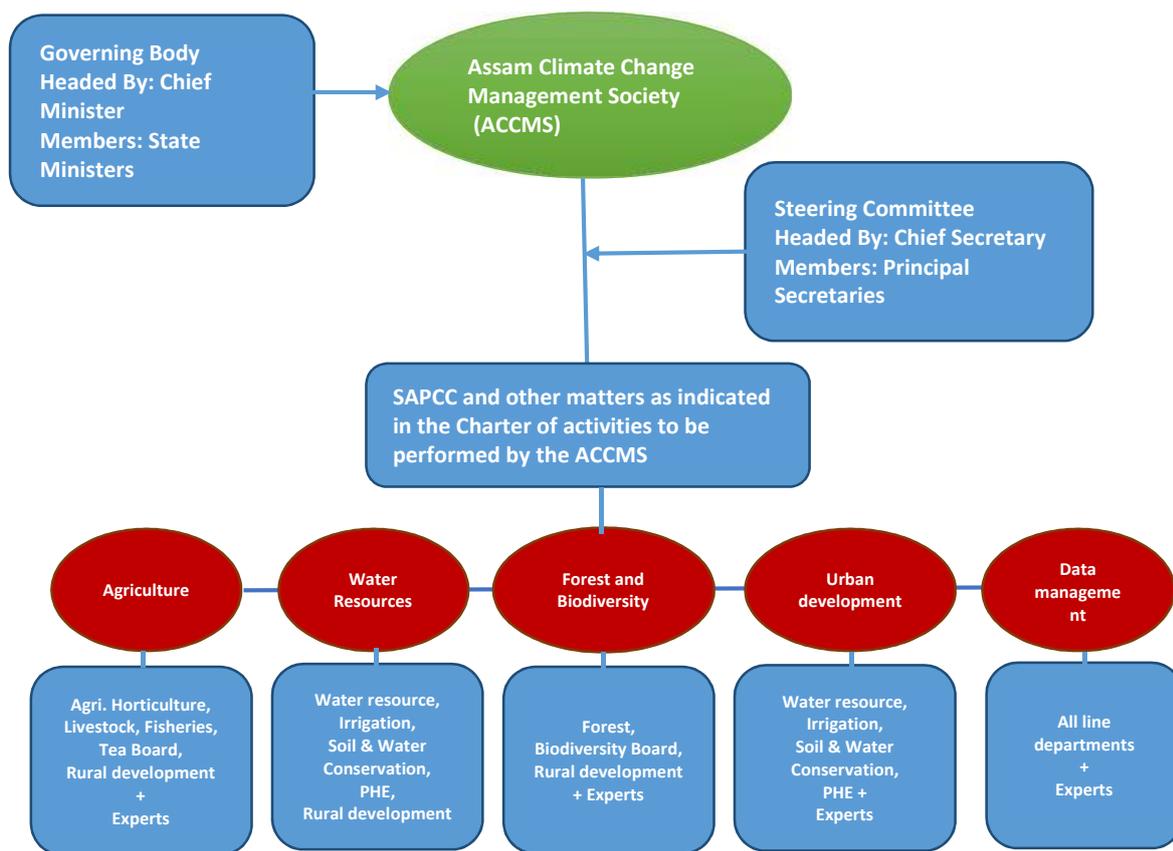
Sr. No	Strategies- Energy Capacity Addition	Implementing Agency	Costs INR in CR	Priority
	Lighting System			
20	Installation of 1 MW aggregate capacity of Solar Wind Hybrid System with capacity ranging from 600 W to 10 kW	AEDA	23.33	M
21	Installation & Promotion of 150 nos. of Solar Water Pumping systems for irrigation purpose	AEDA	9.00	H
22	Electrification of 75 nos. of remote villages through Solar PV based power plant under DDG	AEDA	52.50	VH
23	Setting up 80 MW Grid Connected Solar Power Plant through IPP in BOO Mode	AEDA	800.00	M
	Sub Total- AEDA		996.70	
	GRAND Total- Energy generation		1530.69	

Sr. No	Strategy- Improving Energy Efficiency	Cost (INR Cr)	Sources of fund	Priority	Implementing Agency
1	Explore fiscal mechanisms for supporting energy efficiency activities in the State	0.25		VH	AEDA
2	Ascertain energy efficiency potential in various sectors	0.50		VH	AEDA
3	Energy Conservation in buildings				AEDA
	Customize the ECBC code according to the various climate zones and seismic zones in Assam	0.50		VH	AEDA
	Enforcing BEEs energy conservation building code (ECBC) in all 14 major towns for -efficient lighting systems -Efficient cooling systems -Efficient heating systems	14.00		H	AEDA
	Promote Energy efficiency in religious places through awareness generation	1.00		H	AEDA
	Design fiscal incentives for supporting private owners to follow energy efficiency regulation	0.25		H	AEDA
	Train managers on green building practices and auditing in all the 14 cities	14.00		VH	AEDA
4	Promote energy efficient Household appliances				
	Introduce scheme to replace 4 CFLs with 1 LED - awareness generation.	1.65		H	AEDA
	Tie up with LED producer, recycler.	0.25			

Sr. No	Strategy- Improving Energy Efficiency	Cost (INR Cr)	Sources of fund	Priority	Implementing Agency
	Develop fiscal incentive for the by back process	0.25			
	Ensure presence of only 3 star and above domestic appliances (ACs, fridge) in markets	0.10		VH	AEDA
	Create a mechanism to extract heavy fine from any seller selling Air Conditioner and Refrigerator with energy efficiency that is rated less than 3 star	0.25		VH	AEDA
	Create awareness through media	1.65		VH	AEDA
5	Energy efficiency in Agriculture				
	Only star rated diesel/electricity driven pump sets to be sold in the market-awareness generation and enforcement	1.00		VH	AEDA
6.	Energy efficiency in Industries				
	Identify energy intensive SME clusters and identify energy efficient measures that can be propagated- A study	1.0		VH	AEDA
	Implement the measures through fiscal incentives	0.25			AEDA
7.	Street lighting				
	Promote energy efficiency in street lighting and external lighting in housing societies by introducing LEDs	0.25			AEDA
	TOTAL	37.15			

Way Forward

Implementing SAPCC: It is proposed that a separate Assam Climate Change Management Society (ACCMS) - A Special Purpose Vehicle (SPV) will be created in the State, which will coordinate all SAPCC and other activities related to climate change with different departments in the State. The Society will be having a Governing Council headed by the Chief Minister with council of Ministers as its members and supported by a steering committee chaired by Head of Department of Environment and Forest, Government of Assam.



Implementation Arrangement for the SAPCC

Knowledge Management: Knowledge about climate change, its impacts and associated extent of vulnerabilities, is a matter of strategic importance for all countries as they need to preserve and protect their natural resources, adapt to the changing climate and help contain the concentration of greenhouse gases in the atmosphere at a level that does not dangerously alter the climate system and jeopardize the security of human well-being vis-à-vis its food security, economic security and environmental sustainability. The basic elements of the knowledge management would include

- Capacity Building
- Designing decision support systems
- Research
- Knowledge portal

Some of the knowledge management strategies are listed below.

S.No	Action	Implementing Agency	Costs (INR Cr)	Priority
1	Creating a knowledge Management portal - Assam Climate Change Knowledge portal and continuously update for next 5 years	Assam Climate Change Management Society (ACCMS)	1.50	VH

S.No	Action	Implementing Agency	Costs (INR Cr)	Priority
2	Build capacity within the State to analyse climate change trends and model projections	ACCMS	5.0	
3	Build Capacity to run impact assessment models for various sectors	ACCMS	3.0	
4	Assess district wise Climate Change vulnerability and hydro-meteorological hazard risk and develop adaptation plans for all sectors	ACCMS	1.0	
5	Scan all programs and policies of the government and advise the government as to how all can be made climate resilient.	ACCMS	1.0	
6	Develop advisory manuals on for all infrastructure design requirements to address exacerbated impacts of climate change in the State of Assam in its various regions	ACCMS	1.0	
7	Study & Documentation of ground water level in the piedmont plain of northern Assam- Foot hills of Arunachal and Bhutan	Assam Science and Technology and Environment Council (ASTECC)	0.048	VH
8	Assessment of alternate agri-practices in highly flood prone districts, 19 districts	ASTECC	0.38	H
9	Study of hill-slope destabilisation and urban flood management system (Guwahati City), 1	ACCMS	0.15	VH
10	Policy review in the context of climate change – Forest policy, agri-policy, draft water policy, industrial policy, 4	ACCMS	0.20	H
11	Identification of wetlands for protection and management with proper study on hydrology, flora, fauna and economic value, 4 zones	ASTECC	0.60	VH
12	Identification and conservation strategies of Vulnerable biologically sensitive species, 4 institutions	ASTECC	0.40	M to H
13	Institutional capacity building to handle climate change programmes (all concerned govt. directorates) *, 10 programmes, each 2-3 days	ACCMS	0.50	VH
14	Development of core-group of climate change scientists in Assam (training for	ACCMS	0.60	H

S.No	Action	Implementing Agency	Costs (INR Cr)	Priority
	project development, core-support), 6 institutions			
15	Hazard Risk Vulnerability including impact of climate change assessment including impact of climate change	ASTECC	2.00	
16	Capacity building of departments across all levels of governance towards integrating CC in Adaptation Plans	ACCMS	0.135	VH
17	Education & Awareness on climate change related issues through educational institutions	ASTECC, ACCMS	0.81	
	TOTAL		18.32	

Integrating Climate Change Finance in Planning: Recent modelling by the Asian Development Bank for South Asia suggested that economic growth would be between 2% and 6% lower by 2050 if climate change adaptation is not factored in development. The entire SAPCC budget estimate is indicating a *total fund requirement of INR 58,415.24 Cr over next 5 years, i.e. each year about 11683.04 crores will be spent.* This is only over 7% of the State GSDP at current prices.

This amount can be availing pieces from various sources. If adaptation is not systematically undertaken, then this cost will go on increasing becoming a significant portion of the total GDP. Therefore, it is imperative that adaption cost be factored in each year within planning. Therefore, the next step is to understand how departments can identify and factor in the adaptation budget requirements within their planning. These will then get funding from new fiscal instruments on a regular basis.

List of Figures

1. Chronology of preparation of the Assam SAPCC
2. Implementation Arrangement for preparation of SAPCC
3. Distribution of GSDP in Assam
4. Some of the indicators of developmental gaps in Assam
5. Linking rural population with its share in GSDP of the State.
6. Annual peak discharge for Brahmaputra river from (a) Pandu and (b) Pagladia site
7. Production trends of Rice in Million tons
8. Adaptation Pathway for sustaining agriculture and Horticulture in the State.
9. Horticulture production trends in Assam between 200-01 to 2011-12
10. Percentage area under tea production in different regions of Assam,
11. Tea production trends in Assam in Million tons
12. Bovine and Ovine stock distribution in Assam
13. Fish production Seasonal Milk production trends (in million liters) across different bovine stock in
14. Tea trends in Assam- million tons
15. Distribution of Green cover in Assam
16. Green cover in Assam
17. Location of 13 prominent cities in Assam
18. Location of potable water sources in Assam
19. Trends of growth of road vehicles in Assam, (b) Vehicle mix in 2013-14
20. Climate related disease Incidences reported in Assam in 2009 and 2010
21. Power generation capacity by energy type
22. Implementation Arrangement of SAPCC

List of Tables

1. Climate trends in Assam between 1951 and 210
2. Projected changes in Climate
3. Strategies for meeting water demand in a climate change context
4. Strategies to avert floods in a changing climate scenario
5. Strategies for sustainability of agriculture and horticulture systems in a changing climate scenario in Assam
6. Strategies for sustainable horticulture in a changing climate scenario
7. Strategies for sustainability tea in a changing climate scenario
8. Strategies that Assam would require to combat rising temperatures and emerging pests and diseases.
9. Strategies for sustaining fish production in Assam in a changing climate context
10. Strategies for sustaining Forests and the ecosystem produce from forests in Assam
11. Urban service delivery performance in 13 largest towns in Assam
12. Strategies to address climate change impacts for sustainable water availability – potable and for agriculture
13. Strategies to ensure waste water treatment and solid waste management within urban habitats impacted by climate change
14. Suggested Strategies for the transport sector
15. Strategies for Water ways
16. Strategies for protecting human health
17. Strategies for making urban spaces climate resilient
18. Ongoing projects for capacity addition
19. Strategies for augmenting power demand in the State
20. Some of the Strategies suggested for improving energy efficiency include
21. Climate related disease Incidences reported in Assam in 2009 and 2010
22. Suggested Strategies for the transport sector

Abbreviations

AASC – Assam Administrative Staff College
ACCMS – Assam Climate Change Management Society
ADB – Asian Development Bank
AEDA – Assam Energy Development Authority
AHDR – Assam Human Development Report
APDCL – Assam Power Distribution Company Ltd.
APFCB – Asian Pacific Federation of Clinical Biochemistry
APGCL – Assam Power Generation Company Ltd.
ARI – Acute respiratory Infection
ASAPCC – Assam State Action Plan on Climate Change
ASDMA – Assam State Disaster Management
ASEB – Assam State Electricity Board
ASTC – Assam State Transport Corporation
ASTEC – Assam Science Technology and Environment Council
ASWRC – Assam State Water Resource Council
BEE – Bureau of Energy Efficiency
BL – Base line
BRT – Bus Rapid Transport
CAMPAA – Compensatory Afforestation Fund Management and Planning Authority
CC – Climate Change
CDM – Clean Development Mechanism
CESPR – Centre for Environment, Social and Policy Research
CFL – Compact Fluorescent Lamp
CPHEEO – Central Public Health & Environment Engineering Organization
CNG – Compressed Natural Gas
CR – Crore
CSO – Civil Society Organization
CSS – Central Sponsored Scheme
CWC – Central Water Commission
DALY – Disability Adjusted Life Years
DDL – Disease Diagnostic Limited
DFID – Department for International Development
DoA – Department of Agriculture
DoHF&W – Department of Health and Family Welfare
DoNER – Development of North Eastern Region
DoUD – Department of Urban Development
EPC – Engineering, Procurement and Construction
GDD – Guwahati Development Department
GDP – Gross Domestic Product
GHG – Green House Gas
GIM – Green India Mission
GIS – Geographical Information System
GMC – Guwahati Municipal Corporation
GoA – Government of Assam
GoI – Government of India

GSDP – Gross State Domestic Product
GW – Giga Watt
H – High
Ha – Hectare
HH – House hold
HRF – Horizontal Roughing Filter
IBIS – Integrated Biosphere Simulator
ICAR – Indian Council of Agricultural Research
ICMR – Indian Council Medical Research
IEC – Information and Education Communications
IL & FS – Infrastructure Lease and Finance
IMD – Indian Meteorological Department
INECC – Indian Network for Ethics and Climate Change
IPCC – Inter-governmental Panel on Climate Change
IPP – Independent Power Producer
ISRO – Indian Space Research Organization
IWT – Inland Water Transport
JNNURM – Jawaharlal Nehru National Urban Renewal Mission
KW – Kilo Watt
KNP – Kaziranga National Park
LED – Light Emitting Diode
LPG – Liquefied Petroleum Gas
M – Moderate
MNRE – Ministry of New and Renewable Energy
MoA – Ministry of Agriculture
MoEF & CC – Ministry of Environment, Forests and Climate Change
MoF – Ministry of Finance
MSW – Management Solid Waste
MW – Mega Watt
NABARD – National Bank for Agriculture and Rural Development
NAPCC – National Action Plan on Climate Change
NBA – National Biodiversity Authority
NBPGR – National Bureau of Plant Genetic Resources
NE – North East
NEC – North Eastern Council
NEEPCO – North-eastern Electric Power Corporation Limited
NEIIPP – North East Industrial and Investment Promotion Policy
NESAC – North East Space Application Centre
NMEEE - National Mission on Enhanced Energy Efficiency
NMSA – National Mission for Sustainable Agriculture
NMSH – National Mission on Sustainable Habitats
NMSHE – National Mission on Sustainable Himalayan Eco System
NRHM – National Rural Health Mission
NTFP – Non-Timber Forest Produces
NWM – National Water Mission
OPML – Oxford Policy Management Limited
PA – Protected Areas

PCCF – Principal Chief Conservator of Forests
PHD – Public Health department
PHE – Public Health and Engineering
PRECIS – Providing Regional Climate for Impact Studies
REDD – Reducing Emissions from Deforestation and Forest Degradation
SME – Small Medium Enterprise
SPV – Solar Photo Voltaic
SSS – State Sponsored Scheme
STW – Shallow Tube Well
SWM – Solid Waste Management
TA – Technical Assistance
T&D – Transmission and Distribution
TERI – Tata Energy Resource Institute
THI – Thermal Heat Index
TRAI – Telecom Regulatory Authority of India
TRI – Tea Research Institute
ULB – Urban Local Bodies
VH – Very High
VVH – Very, Very High
WATSAN – Water and Sanitation
WW – Waste Water
WRD – Water Resources Department
W.R.T. – With respect to
WTP – Water Treatment Plant

SECTION A: INTRODUCTION, STATE PROFILE AND VULNERABILITY DUE TO CLIMATE CHANGE

1. Background

Records of the Indian Meteorological Department (IMD) assessed over the last 112 years in India, indicate a discernable increase in ambient temperature of the order of 0.60°C¹, increase in heavy rainfall events and decrease in low and medium rainfall events². Changes in rainfall and temperatures have also been reported by various other researchers^{3,4,5}. Projection indicate that warming is likely to continue and the impacts are likely to manifest more severely in the tropical countries such as India⁶.

As climate dependent natural resources play a critical role in our socioeconomic development, India drafted its National Action Plan on Climate Change (NAPCC) in 2008. The Action Plan identifies the vulnerabilities of India due to climate change and lays out an overarching approach to adapt to the impacts through

- Missions on Water resources,
- The Sustainable Agriculture Mission
- The Green India Mission that aims to make forest and biodiversity climate resilient
- The National Mission on Himalayan Ecosystem
- The National Mission on Habitats

The NAPCC also focuses on improving energy efficiency in industry and buildings and lays down the pathway for increasing share of solar power in the total energy mix. Following this, the States in India started drafting their respective State Action Plan on Climate Change. The additional two missions therefore are:

- Enhanced Energy Efficiency Mission
- Solar energy missions

Government of Assam recognizes that Climate Change can throw up challenges impacting its developmental aspirations. With this in view, it started preparing its State Action Plan on Climate Change. Given the unique physiography and climate vis a vis its location in the North Eastern Himalayas with mighty Brahmaputra flowing through the State, and the fact that it is subjected to recurrent floods, the Stake holder consultations concluded that continued warming of the atmosphere and ensuing changes in precipitation pattern is impacting the State's water resources, agriculture, forest, its unique biodiversity and the habitats where people live. The emerging pattern of enhanced intensities of rainfall and drought periods are further exacerbating the impacts and thus making the State economically vulnerable.

¹Attri, S.D. and Tyagi, A., 2010. "Climate Profile of India". Met. Monograph Environmental Meteorology No 1/2010, pp. 1-122

²Goswami, B.N., Venugopal, V., Sengupta, D., Madhusoodanan, M.S. and Xavier, P. K., 2006 "Increasing trend of Extreme Rain Events over India in a Warming Environment". Science, 314, 5804, 1442-1445

³Guhathakurta, P. and Rajeevan, M., 2008. "Trends in the rainfall pattern over India". Int. J. Climatol., 28, 1453-1469

⁴Dash, S.K., Kulkarni, M.A., Mohanty, U.C. and Prasad, K., 2009. "Changes in the characteristics of rain events in India". J. Geophys. Res., 114, D10109, doi:10.1029/2008JD010572

⁵NATCOM, 2012. "India's Second National Communication to the UNFCCC". Ministry of Environment and Forests, Government of India, New Delhi

⁶Sathaye, J., Shukla, P.R. and Ravindranath, N.H., 2006. "Climate change, sustainable development and India: Global and national concerns". Current Science, 90, 3, 314-325

2. Principles

The Strategies identified to for adapting to climate change are based on assessment of vulnerability of the State largely based on available scientific literature. The strategies formulated are essentially the various response measures formulated to address the exacerbated impacts of climate change and future trajectories of socio-economic change, in consultation with concerned departments and expert advice.

The State Action Plan on Climate Change (SAPCC) is being prepared with the objective of identification of adaptation strategies that will make the State resilient, to the extent possible to the ongoing climate variability, climate change and associated extreme events. It is perceived that developing climate resilience would not hamper the State's developmental aspirations. It aligns itself with the guidance provided by the missions of the National Action Plan on Climate Change and the principles of adaption followed while developing the Assam SAPCC are as follows:

1. **Ensuring sustainability of water resources:** Water being essential to all economic activities, the SAPCC looks at how water resource can be augmented and best utilized in a changing climate scenario and what necessary institutional changes will be required to make these strategies come to affect.
2. **Ensuring sustainability of agriculture systems:** Major concerns are sustainability of critical ecosystems including agro-ecosystems (agriculture, fishery, and livestock) to ensure livelihood security in a changing climate scenario.
3. **Protection and conservation of forests and bio resource within:** Focus areas are sustainable management of Forest, Wild Life and biodiversity and developing resilience of eco-system services.
4. **Making habitats climate resilient:** Major concern is the expanding and high density urban human settlements where proving sanitation, drinking water, transportation, health, waste management and other amenities will be a challenge in the future changing climate scenario.
5. **Ensuring 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. **Addressing enhanced impacts of anticipated extreme events:** Adaptation planning in anticipation of intensification of extreme events to ameliorate the exacerbated impacts will be the underlying motto here.

3. Process of Preparation of SAPCC

Figure 1 depicts the chronology of preparation of the SAPCC in Assam. The entire process has been coordinated by the Department of Environment and Forests, Government of Assam which is the nodal for climate change matters in the State. A Steering committee, with members nominated from various line departments and chaired by the chief secretary oversees the preparation of the Plan. Further working groups were formed on

- o Agriculture: Members – Agriculture department, Horticulture, Animal Husbandry, Fisheries, Tea Board, Agriculture University;

- Water resources and Floods: Members- Water Resources Department, Irrigation department, Public Health department, University of Guwahati; Assam State Disaster Management Authority (ASDMA)
- Forest and Biodiversity: Forest Department, Biodiversity Board, Tourism, ASDMA
- Habitats: PHE (Public Health & Engineering), Urban Development Department, Health and Family Welfare, Inland Water Transport, Road Transport, ASDMA Town and Country Planning Department.
- Enhanced Energy Efficiency and Renewable Energy: Department of Power, Assam Energy Development Authority, Assam Power Distribution Company Limited, Assam Power Generation Company Limited

The members of these working groups were drawn from the various departments, prominent NGOs and research institutions. Figure 2 depicts the implementation arrangement for the preparation of the Assam SAPCC. Further, the SAPCC contents were discussed with larger group of Stakeholders such as Research institutions, NGOs and individual experts through various forums [See Annexure 1 for List of Stakeholder Consultations]. Any comments received have been incorporated within the document.

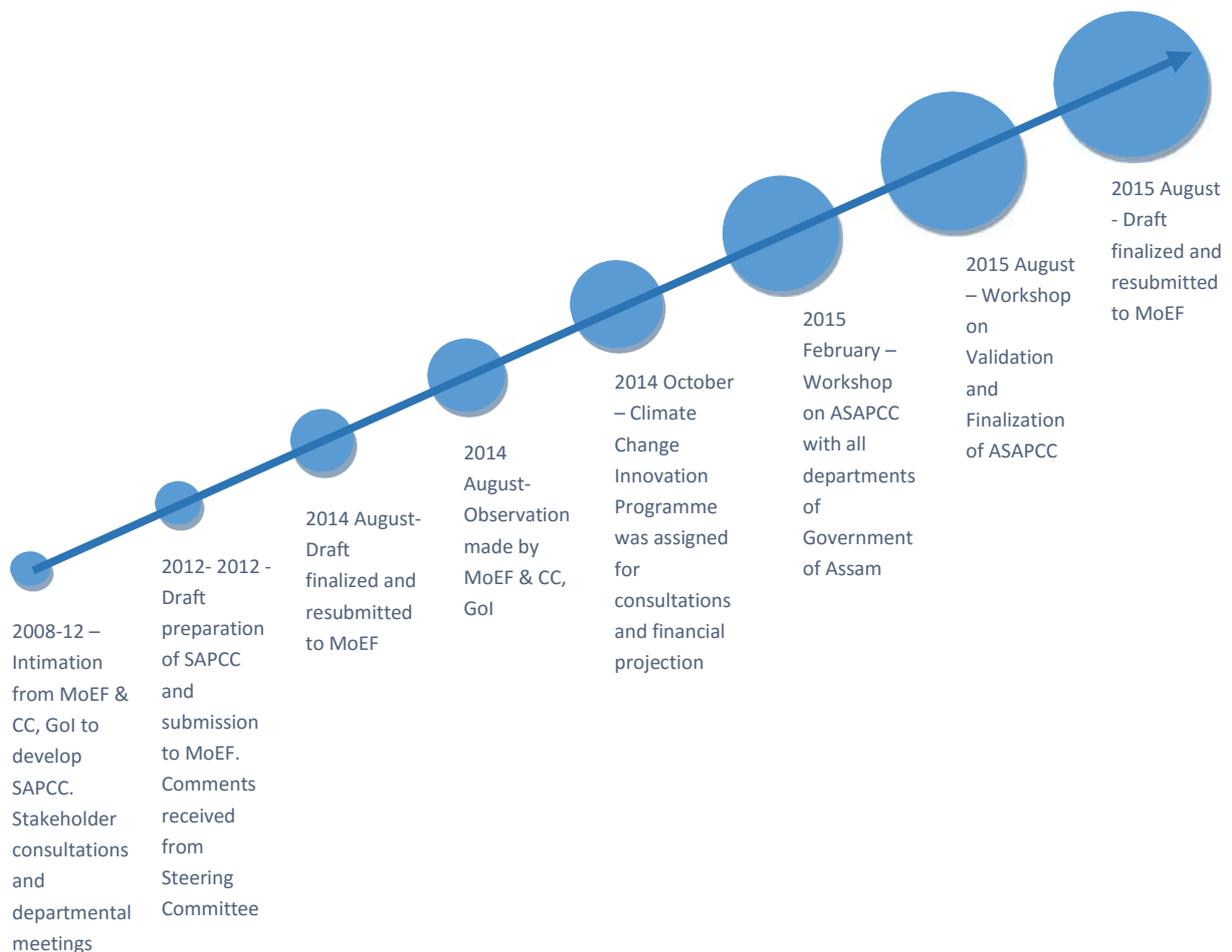


Figure 1: Chronology of preparation of the Assam SAPCC

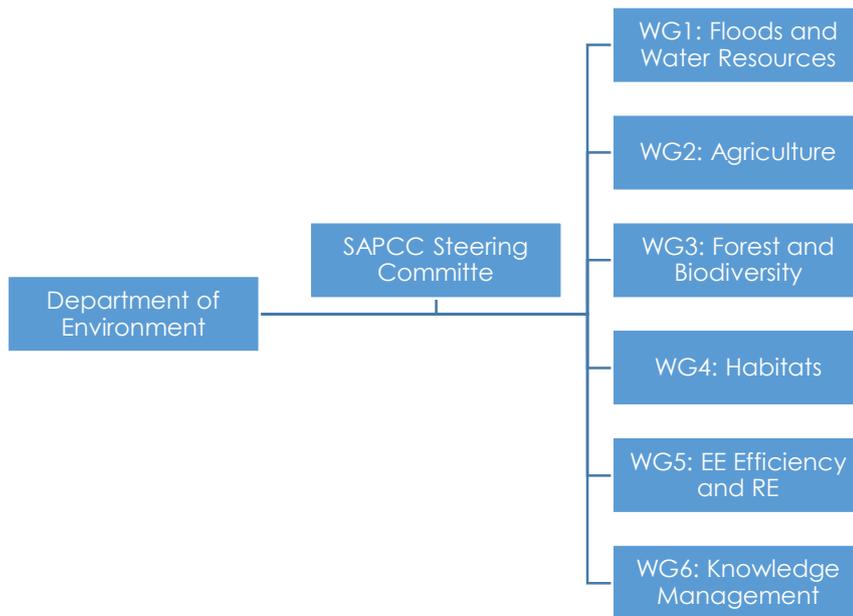


Figure 2: Implementation Arrangement for preparation of SAPCC

4. State Profile

4.1 Geophysical 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 undulating topography. The State is surrounded by 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 88.25°E to 96.0°E and latitude at 24.5°N to 28.0°N and temperature varies from 6°C to 38°C. 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 Lakhimpur 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.

4.2 Natural Resources

Assam lying in the eastern Himalayas is blessed with fertile soil and a moist tropical climate enabling it to have a treasure trove of biodiversity. 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). Assam is also 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*).

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 the National Bureau of Plant Genetic Resources (NBPGR) as being rich in wild relatives of crop plants. Agricultural Research (ICAR) as a center 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 State is also very rich in medicinal plants. As many as 952 plant species of medicinal value are found in Assam (Department of Environment and Forests, Undated).

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). 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 harbors 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. 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

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.

4.3 Demographic Profile and its Spread

According to the 2011 census, Assam's 32.17 million people⁷ account for 2.58% of the country's population with its population density being marginally higher than the average density of the country. The growth rate of population between 2001 and 2011 by 16.93 per cent. This is lower than the overall national growth percentage of 17.64. Large scale migration from Bangladesh continues into the State. 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).

Assam has the largest urban population of 4.3 million people amongst the North-eastern States, which accounts for 14% of the total States population. The largest urban agglomerates are the cities of Guwahati with 0.9 million people, Nagaon (0.12 million), Dibrugarh (0.04 million) and Silchar (0.17 million).

A brief on Assam population Statistics is given below.

Table 1: Population Statistics as per 2011 Census

⁷<http://online.assam.gov.in/web/population-census>

	Assam	India
Total Population (million)	31.17	1210
Population Density (person/sq. km)	397	382
Decadal Growth Rate of population (2001-2011)	16.93%	17.64%
Female Percentage (Percentage of total population)	48.8%	48.5%
Sex Ratio (females per thousand males)	954	940
Literacy Rate	62.5%	74%
Urban Population (share in total population)	14%	12.9%

4.4 Economic Profile

Assam is the seventh fastest growing state and the 12th Five Year Plan estimates the growth rate to be around nine per cent. At current prices, the Gross State Domestic Product (GSDP) of Assam was INR 159460 Crores in 2013-14. The GSDP across sectors is shown in Figure 3.

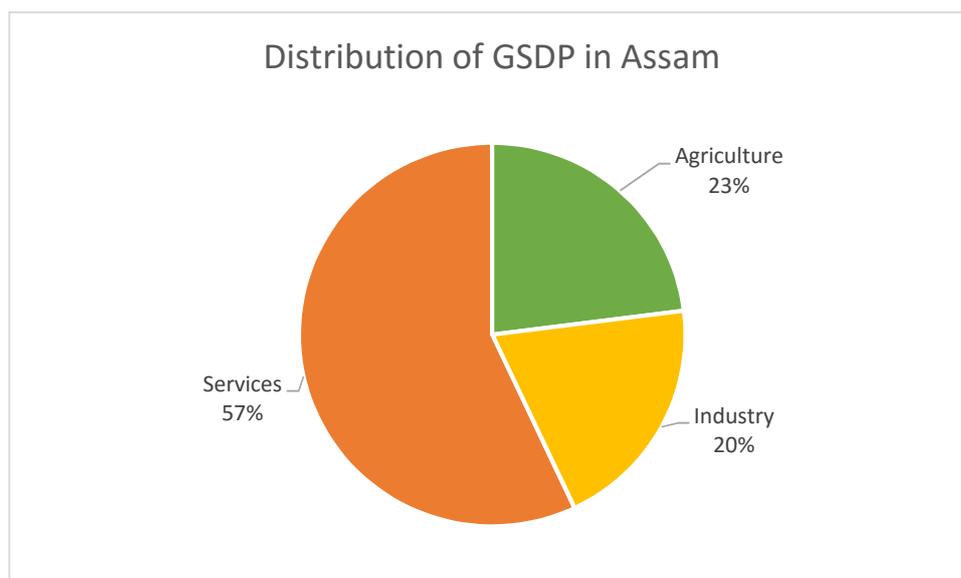


Figure 3: Sectoral Distribution of GSDP in Assam

About 49.34% of the working population is engaged in Agriculture and allied services⁸. Rice is the main cereal produced and about 105 million tons of rice was produced in 2012-13. The next brig crop is sugar cane, the production of which was 314 million tons during the same period². The Tea industry plays a vital role in the State as well as national economy. The tea production in Assam constitutes more than 50 percent of the total production of the country (Economic survey, Assam, 2009-10). Assam is also the third-largest producer of petroleum and natural gas in the country and has ample reserves of limestone. Bamboo artifacts, Muga silk, paper are some of the other natural resource based industries thriving in the State. With its five national parks and

⁸Statistical Handbook- Assam, 2014

15 wildlife sanctuaries, the state is a biodiversity hotspot and therefore this is a potential area of growth.

Assam has adopted numerous investor-friendly policies to attract investments and accelerate industrial development. Key areas of focus include the IT, tourism and power sector along with several other initiatives such as the North East Industrial and Investment Promotion Policy (NEIIPP) 2007 and the Industrial and Investment Policy 2014.

4.5 Physical and Social Infrastructure

The development in the power sector holds the key to its becoming one of the fastest growing States. As per 2013-14 status, Assam generated 1845.228 MU of electricity and the demand was 7434 MU. About 11% deficit in peak demand in power was registered in 2013-14⁹. Assam has procured US\$ 200 million from Asian Development Bank (ADB) for its Power Sector Enhancement Investment Programme. Besides, ADB has provided a grant of US\$ 1 million for capacity development of the power-sector utilities in the state⁹.

About 49239.673km road connects Assam through its length and breadth. The navigable waterways in Assam through which passenger and freight transportation also takes place, extends over 1000 kms covering Brahmaputra and Barak rivers. The river Brahmaputra is known as the National Waterway No 2 (The Ganges is known as the National Waterway No 1)¹⁰. Railway route length covers a distance of 64.6 thousand kms and 6 airports are spread across the State.

According to Telecom Regulatory Authority of India (TRAI), Assam had nearly 16.43 million wireless subscribers and 0.178 million wire-line subscribers, as of December 2014¹¹. In 2010-11, the state had 35,065 primary schools, 12,985 middle schools and 5,714 high schools. The State Government is taking several steps to encourage setting up of various educational complexes for skill development.

About 38 government hospitals, 1196 health centers and 4609 sub centers dot the state, with a bed strength of 11,459 beds, i.e., one bed per 2720 persons is available. About 3574 doctors are practicing in the State, i.e., 1 doctor is available for every 8700 persons.

⁹<http://www.ibef.org/download/Assam-110313.pdf>

¹⁰Directorate of Inland Water Transport of Assam

¹¹<http://www.trai.gov.in/WriteReadData/WhatsNew/Documents/PR-TSD-120315.pdf>

5. Observed Changes in Climate and Projections

5.1 Observed weather and Climate trends

With the "Tropical Monsoon Rainforest Climate", Assam is temperate (summer max. at 35–39 °C and winter min. at 5–8 °C) and experiences heavy rainfall and high humidity. The climate is characterized by heavy monsoon downpours, which reduce summer temperatures, enable formation of foggy nights and mornings in winters. Spring (Mar–Apr) and autumn (Sept–Oct) are usually pleasant with moderate rainfall and temperature.

For ascertaining long term climate trends, State level climate data for the period 1951 to 2010 has been analyzed by the India Meteorological department¹². This analysis is based on 282 stations for temperature and 1451 stations for rainfall across the country. In Assam, the analysis is based on data collected from 6 Stations for temperature and 12 Stations for rainfall. The analysis indicates that the mean temperature in the State has increased by +0.01°C/year. There is also an increase in seasonal temperatures across seasons with pronounced warming in post monsoon and winter temperatures. The annual rainfall has also decreased by -2.96 mm/years during the same period. There

Table 1: Climate trends in Assam between 1951 and 2010

	Annual	Winter	Summer	Monsoon	Post Monsoon
Mean Max Temp (°C/yr)	+0.02	+0.01	No trend	+0.01	+0.02
Mean Min Temp (°C/yr)	+0.01	+0.02	+0.01	+0.01	+0.02
Mean Temp (°C/yr)	+0.01	+0.01	No trend	+0.01	+0.02
Rainfall (mm/yr)	-2.96	+0.08	-0.56	-2.19	-0.75

Additionally, when station wise data are analyzed for a period of 25-30 years at least, significant variations are seen across seasons in number of rainy days and in 24 hr maximum rainfall¹³. As per the guidelines of IMD, a rainy day is defined as that day which receives rainfall amount of more than 2.4 mm. The 24 h maximum rainfall is defined as the highest amount of total rainfall (in millimeter) occurring in a day in particular year over a particular station.

¹²Rathore L S, A D Attri and A K Jaswal, 2013. State Level Climate Change Trends in India. Meteorological Monograph No. ESSO/IMD/EMRC/02/2013. India Meteorological Department. Ministry of Earth Sciences. Gol

¹³Jhahj3aria D, B K Yadav, S Maske, S Chattopadhyay, A K Kar, 2012. Identification of trends in rainfa4ll, rainy days and 24 hr max rainfall over subtropical Assam in NE India. C R Geoscience 344 (2012) 1-13

It can be seen from Table 2 that both upward and downward trends are experienced in the 24 hr maximum rainfall in Assam. Only two stations witnessed statistically significant trends. The decreasing trends in the 24 h maximum rainfall events at 5% level of significance were observed at Rangia and Haflong. The 24 h maximum rainfall has decreased to 43 mm at Rangia and 68 mm at Haflong for the total period of records available at these two sites. As regards the number of rainy days, on annual time scale, only two stations (Majbat and Mathungari) witnessed statistically significant decreasing trends in the rainy days at 5% level of significance. Similarly, on seasonal time scale, eight and six stations witnessed statistically significant decreasing trends at 5% level of significance in the number of rainy days in monsoon and post-monsoon seasons, respectively. The results of analysis of trends in rainy days in winter and pre-monsoon seasons reveal that the majority of the stations observed statistically non-significant trends obtained through the MK test at 5% level of significance in the rainy days.

Though long term analysis is not picking up any trends in increase in extreme rainfall events but two extremely intense cloud bursts of unprecedented intensity- one in the western Meghalaya hills and Western Arunachal Pradesh in 2004 produced two devastating flash floods in the Goalpara and Sonitpur districts of Assam bordering Meghalaya and Arunachal respectively causing hundreds of deaths and enormous loss to the animals and agriculture.

Table 2: Trends of number of rainy days and 24 hr maximum rainfall across various rain-gauge Stations in Assam¹³

Region in Assam	Sr no.	Station	District	Rainy Days					24 hr Max rainfall
				Annual	Winter	Pre-Monsoon	Monsoon	Post-Monsoon	
West Assam	1	Dhubri	Dhubri	0.15	1.04	0.10	-0.63	0.35	-1.32
	2	Goalpara	Goalpara	0.03	0.16	-0.93	-0.96	-0.19	-1.62
	3	Goibargaon	Nalbari	0.83	-1.03	0.75	0.32	-1.97	1.19
	4	Guwahati	Kamrup	-0.42	0.06	-0.75	-1.67	-1.67	0.17
	5	Rangia	Kamrup	-0.61	-1.53	0.19	-0.96	-1.02	-2.09
	6	Mathungari	Barpeta	-2.17	-2.53	-0.52	-2.22	-2.25	-0.75
	7	Panbari	Bongaigaon	0.40	-0.66	0.24	-0.24	-1.45	0.01
NC, Assam	8	Dahrmatala	Morigaon	0.04	-0.29	-0.92	0.72	-1.58	0.50
	9	Gohpur	Sonitpur	0.34	-0.12	-0.62	-0.43	0.29	0.55

Region in Assam	Sr no.	Station	District	Rainy Days					24 hr Max rainfall
				Annual	Winter	Pre-Monsoon	Monsoon	Post-Monsoon	
	10	Golaghat	Golaghat	-1.61	-1.23	-1.30	-1.40	-2.00	-1.23
	11	Majbat	Darrang	-2.80	-1.16	-1.52	-2.82	-1.69	-0.49
	12	Tezpur	Sonitpur	-0.14	-0.34	-0.55	-0.43	-2.65	0.85
Eastern Assam	13	Digboi	Tinsukia	-1.09	-1.20	-0.34	-2.15	-1.68	-0.74
	14	Lilabari	Lakhimpur	-0.06	-0.96	0.13	0.54	-2.12	0.11
	15	Nimatighat	Jorhat	-1.15	0.43	-0.55	-2.02	-2.53	-1.07
	16	Sivasagar	Sivasagar	-1.37	0.11	-0.20	-2.75	-1.44	-1.07
Southern Assam	17	Halflong	N Cachar Hills	-1.80	0.77	-1.92	-2.28	-0.38	-2.03
	18	Kheronighat	Karbi Anglong	0.02	1.43	-0.04	-0.68	-1.09	0.55
	19	Lumding	Nowgaon	-0.58	0.72	0.39	-2.39	-0.75	-1.75
	20	Silchar	Cachar	-1.12	0.28	-0.75	-2.07	0.69	-1.57

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

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

5.2 Climate Projections

District level climate projections are available across Assam¹⁴ driven by A1B scenario¹⁵ for the period 2021–2050 using regional climate model PRECIS, a model developed by the Hadley Centre, UK Meteorological office. The resolution of the model is 50kmx50km.

It is to be noted that such projections are only indicative in the very broadest sense of the changes that are likely in the climate as high level of uncertainties are associated with the projections, indicating the need for further research on these aspects.

Table 3 below shows the projected changes in various climate parameters till mid-century. Temperatures continue to rise and may increase by 1.7-2.0°C w.r.t. to base line (BL). Only the western part of the State will experience slight decrease in rainfall but the rest of Assam is projected to have increase in rainfall. There is likely to be increase in extreme rain fall event by 5% to 38% w.r.t. to base line. Droughts weeks are going to rise, with Southern districts showing marginal reduction in drought weeks but rest of the district show an increase by more than 75% w.r.t. BL. As regards floods, they are going to rise by more than 25% in the southern parts of Assam (see Table 2).

Table 3: Projected changes in Climate

	2021-2050 wrt BL	Remarks
Mean Temperature	1.7-2.0°C	All across Assam
Annual Rain fall	-5 to 5%	North western districts
	5-10%	North Eastern districts
	10-25%	Central, South Eastern Districts

¹⁴http://www.mdoner.gov.in/sites/default/files/silo2_content/Kfw/Project_Document_NECCAP-31052011.pdf

¹⁵Parry, M. L., Canziani, O. F., Palutikof, J. P., Van der Linden, P. J. and Hanson, C. E. (eds), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK, 2007, p. 976.

	2021-2050 wrt BL	Remarks
Extreme rainfall days	5-38%	Rainfall >25 to 150 mm
Drought weeks	-25% to >75%	Southern districts show marginal reduction in drought weeks but rest of the district show an increase by more than 75% wrt BL
Floods	Stream flow <10% to >25%	Min in North East and Max in Southern part of the State

6. Vulnerability of the State

As per the IPCC working group II report¹⁶, vulnerability can be defined as the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Therefore, the inability to cope with changing climate conditions is generally contextual and is a characteristic of the existing developmental paradigm, and that of the social and ecological systems amongst others. Keeping this in view we try and assess the developmental gaps to have a feel of the vulnerability of the State to climate change. Also as economic capacity is the basic driver that ensures adaptation to an extent, this aspect also has been explored here.

6.1 Physical Vulnerability

The reform process initiated since 2003 seems to have contributed to the economic growth of Assam during the 10th plan period, and therefore to an extent, we can say that Assam has developed resilience to cope with climate change. However, still in 2011-12, as 31.98% of the State's population lived below the poverty line against all India average of 21.92%, with majority of the population, especially the people living in interior rural areas, in areas inhabited by Scheduled Caste & Scheduled Tribe population, tea garden areas and far flung "char" (riverine) lack facilities of safe drinking water, sanitation etc. These developmental gaps the communities vulnerable to climate change. Figure 4 shows the developmental gaps that Assam would need to bridge to enable it to address climate change vulnerability.

¹⁶IPCC-AR5, 2014. Impacts of Climate Change- Working Group II report.

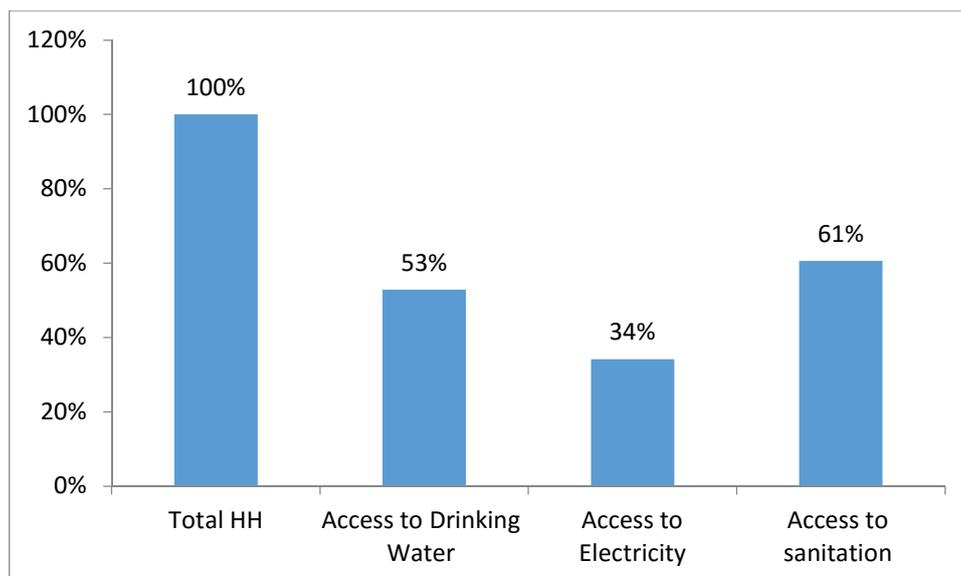


Figure 4: Some of the indicators of developmental gaps in Assam
 Source: Assam Statistical Handbook, 2014, Planning department, Gov. of Assam.

At a micro scale, as per The Ministry of Development of North Eastern Region (DoNER) and the North Eastern Council (NEC) 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 as climate change continues, these islands will become increasingly vulnerable and hence public health facilities need to be extended to such areas effectively.

Strategies have been formulated to overcome these developmental gaps. But the phenomenon of climate change provides another dimension to the existing challenges by introducing risks to the inherent resilience of natural systems such rain dependent resources - potable water availability and accessibility to electricity from hydropower which currently constitutes of 24% of the total electricity produced in the State. Policy making in such a context has to deal with uncertainty and critical gaps in knowledge.

Assam's economy is still agrarian as 86% of its rural population is dependent on agriculture and allied activities such as agriculture, fisheries and forests, which together contribute 34% of the GSDP, and combining mining and quarrying the primary sector has a share of 42% in the total GSDP of the State (see Figure 5). This is a large value compared to many States in India, where the secondary and tertiary sectors constituting of construction and services sector respectively are having larger shares, as compared to the primary sector.

In the future agriculture economy will continue to dominate, as Assam would like to ensure its food security through domestic production and

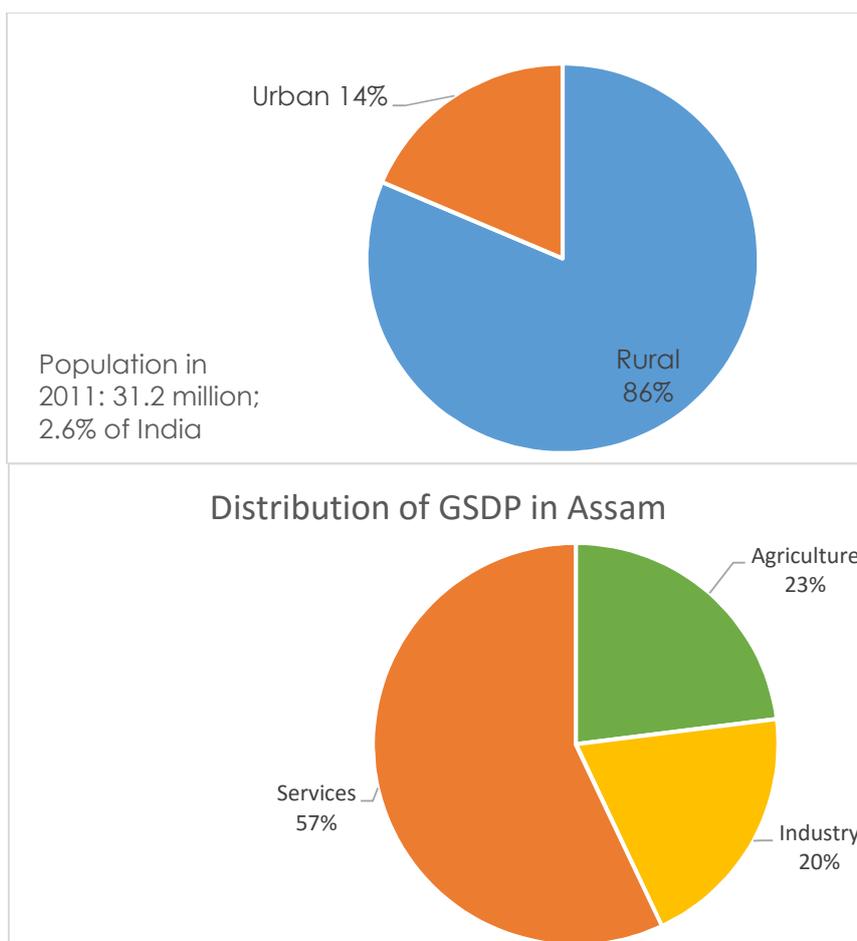


Figure 5: Linking rural population with its share in GSDP of the State
 Source: Assam Statistical Handbook, 2014, Planning department, Gov. of Assam.

Create maximum employment in this sector¹⁷. However, high decadal population growth rate of 17.43% (compared to National average growth rate of 16.93%), the current practices such as over exploitation of ground water, *Jhum* cultivation in hilly areas, mono cropping etc. and recurrent floods and droughts are putting pressure on the agriculture system. Exacerbation of climate change induced hazards are likely to further make the agriculture production system of the State uncertain, and these issues need to be addressed within the developmental plans of the State.

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.

Forests can improve ground water recharge, reduce soil erosion and runoff, regulate flooding and temperature of a place. Assam forest and tree outside forests together

¹⁷http://www.agriassam.in/etc/state_agriPolicy.htm

cover 37.29% of the States geographical area. Recent reports¹⁸ indicate that area is Increasing under moderately dense forests and open forests especially in tribal dominated district lying in the hilly areas adjoining Arunachal Pradesh, Nagaland and Meghalaya, Dependency on fuel wood, mining, logging, urbanisation, encroachment, higher frequency *Jhum* cultivation etc. are some of the developmental factors leading to degradation of forests. As floods and droughts are likely to intensify, it is very likely that a further reduction in forest cover may occur in these areas and may amplify the impacts on agriculture, water resources and the composition of the remaining forestland.

Finally, it is clear that effects of climate change will be felt most strongly by the poor. 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.

6.2 Anticipated Economic Vulnerability

There has been little analysis of the economic impact of climate change in Assam. However, some assessment is possible, based on the analysis that has been done elsewhere in South Asia. Recent modelling by the Asian Development Bank (ADB) for South Asia suggested that economic growth would be between 2% and 6% lower by 2050, depending on which climate change scenario happens and on the extent to which the wider impact on health and environment is taken into account. This economic impact is likely to be felt in small gradual steps, each year, but these steps are cumulative and the combined effect will be that GDP will be only two or three times higher in 2050, rather than five times higher if 5% growth is sustained.

The key sectoral contributions to the economic impact of climate change are as follows.

Agriculture will see the largest economic impact. For South Asia as a whole, the agricultural impact is likely to reduce GDP growth by about 2%, partly as a result of temperature trends and partly because of more variable and unpredictable rainfall. In Assam, the net economic damage in the agricultural sector is likely to be roughly similar to the South Asian average. Loss from temperature trends may be lower, because extreme temperatures are less common, but the State is more vulnerable than most states to loss from rainfall variability and because agriculture contributes a higher than average share of State GDP.

Loss and damage in the forestry sector is likely to be higher than average in Assam, because of the large forest area. However, there is limited evidence on the net impact of climate change on forests, even at a South Asian level, and insufficient evidence to provide an estimate of economic impact. If mechanisms could be created to provide payments for mitigation benefits, these could add 5% to 10% to forestry GDP, based on the relative value of net carbon sequestration, compared with commercial benefits from forestry.

¹⁸State of the Forest Report 2013, Forest Survey of India, Ministry of Environment and Forests, Government of India

There are likely to be some losses in the energy sector, partly from less reliable hydropower generation and partly because of increased losses from distribution in higher temperatures. The net impact on hydro power requires further study, but international evidence on losses from distribution suggests they could amount to up to 0.05% GDP.

Climate change will result in more frequent and severe floods which will increase the costs of reconstruction and maintenance on State infrastructure, including roads, irrigation, water and sanitation. Evidence for South Asia suggest that the total capital value of infrastructure is about 30% of GDP and that annual rehabilitation and maintenance costs are between 1% and 3%. If these costs double, in line with the increased frequency and severity of floods, then the economic cost of climate change on infrastructure would grow to between 0.3% and 0.9% of GDP by 2050.

The increase in flooding will also increase loss and damage to domestic and industrial property and will affect labour productivity and result in increased health burden and loss of life and injury. There is no estimate of the scale of this impact in South Asia, but evidence from South East Asia suggests that flood damage can average about 0.75% of GDP annually in areas that are vulnerable to flooding. Given the vulnerability of Assam to flooding it seems unlikely that the economic impact in Assam will be lower than this.

The evidence from South East Asia suggests that climate sensitive diseases result in the loss of about 27 Disability Adjusted Life Years (DALYs) per 1000 people, including loss of productivity through ill health and loss of life. International evidence from World Health organisation (WHO) suggests that climate change in tropical areas is likely to increase the incidence of climate sensitive diseases by about 10%. India does not yet have a yardstick for valuing DALYs, but the WHO yardstick is three times per capita GDP, which would suggest that the increase in health burden would impose economic costs of about 0.81% of GDP by 2050.

SECTION B: ADAPTING TO CLIMATE CHANGE

7. Water Resources

The main objective of the National Water Mission (NWM) is “conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management”. The five identified goals of the Mission are: (a) developing comprehensive water data base in public domain and assessment of impact of climate change on water resource; (b) promotion of citizen and state action for water conservation, augmentation and preservation; (c) focused attention to vulnerable areas including over-exploited areas; (d) increasing water use efficiency by 20%, and (e) promotion of basin level integrated water resources management (IWRM).

Keeping in view the guidance provided by the Water Mission, this chapter 1st reviews the water resources situation in Assam, then assesses the vulnerabilities of water resources associated with climate change and then identifies the adaptation strategies in line with the tenets of the National water mission wherever possible.

7.1 Water availability

About 8251 sq. km, which is 10.5% of the total geographical area of the State, is occupied by surface water bodies¹⁹, of this about 6503 sq. km is occupied by the river systems including the mighty Brahmaputra and 1748 sq. km by natural wetlands including seasonal and permanent waterlogged and marshy areas and man-made areas.

The Brahmaputra is the 6th largest river in the world. It is amongst the most flood prone rivers, and with its 41 major and 121 minor tributaries that flow to Assam represents a most complex river system. Another major river in Assam, i.e., Barak, originates from Japvo mountain of Manipur hills at an altitude of 3,015 m and flows south through mountainous terrain up to Tipaimukh near the tri-junction of the three states: Assam, Manipur and Mizoram. Here, the river takes a hairpin bend and plunges into the plains of Cachar district of Assam and forms the border of Assam and Manipur states up to Jirimat, which is upstream of Lakhipur. The river then flows through the Barak Valley of Assam. From the source to the Indo-Bangladesh border, the Barak River flows for 564 km. In Assam, the Barak river basin covers an area of 7,224 kms.

Ground water is available at low to moderate depth almost in entire state. Annual Groundwater in Assam is estimated to be 5.44 billion cubic meter²⁰ of which 4.85 billion cubic meter is for irrigation and 0.59 billion cubic metre¹⁸ is for domestic and industrial uses. The overall Stage of Groundwater Development in the State is 22% - with the lowest figure of 2% in Cachar District and highest 56% in Bongaigaon District - and has been categorized as 'safe'.

Although there is seasonal and regional variation in the availability of water resources, the annual availability of water resource remains almost same. As per Amarsinghe, 2004²¹,

¹⁹Das Prasenjit, 2012. WATER RESOURCES AND RESERVATION POLICIES IN ASSAM. International Journal of Science, Environment and Technology, Vol. 1, No 1, 19-23

²⁰Das Prasenjit, 2012. WATER RESOURCES AND RESERVATION POLICIES IN ASSAM. International Journal of Science, Environment and Technology, Vol. 1, No 1, 19-23

²¹Amarsinghe, 2004. Spatial variation in water supply and demand across the river basins of India. International Water Management Institute, Sri Lanka.

- Withdrawal of water for irrigation is 81% of the total water available in the Brahmaputra basin
- for meeting domestic water demand only 10% of water is withdrawn and
- for industrial activities only 9% of water is available

An assessment of the impact of climate change on the hydrological regime and water resources using scenarios from IPCC and running on Hadley center regional climate model indicates that by year 2050, the average annual river runoff of the river Brahmaputra will decline by 14%. However, earlier to this there is a risk of melting of glaciers leading to flash floods. Therefore, some of the concerns on water resource availability center around:

Ensuring water for irrigation in long dry period. The ratio of gross irrigated area to gross cropped area has declined over the years and secondary crops are no longer irrigated due to lack of adequate facilities. During moisture stress, the fields are of the order of only 1 ton/ha as compared to 304 tons/ha elsewhere.

Meeting demand for fish. Extreme rain fall, may not enable filling up of enough water in the tanks to meet the future fish demand of the State, which already is not able to meet the demand of its population in the present context.

Meeting the demand of industry. With increase in proposed capacity generation of thermal power, biomass power, biogas power and increasing the industrial base, meeting demand for industry might be a challenge

Meeting potable water demand. The population is likely to rise continuously and only likely to peak in the 2050s, the rising demand in potable water has to be met by devising strategies that harp on new technologies of water recycling amongst others.

Table 4: Strategies for meeting water demand in a climate change context

Sl. No	Strategy	Responsible Agency and time period	Cost (INR Cr)	Priority	Possible Financing Source
1	Undertake assessments to ascertain the institutional reforms requires to address water generation, distribution, and use issues in a climate change context	Deptt of water Resources PHE Irrigation	0.50	VH	Climate change fund mechanism
2	Set Up Assam State Water Resource Council		-	H	Climate change fund mechanism
3	Assess the amount of water use efficiency taking place by applying the following in one location wrt base line and replicate in later years <ul style="list-style-type: none"> - Reuse of waste water (1000 ha) - Water efficient crops (1000 ha) 	Deptt of agriculture	1.00 0.50 0.30	VH	Climate change fund mechanism

Sl. No	Strategy	Responsible Agency and time period	Cost (INR Cr)	Priority	Possible Financing Source
	- SRI or multiple aeration for rice cultivation (1000 ha)				
4	Improve water efficiency through conjunctive use of surface and ground water over at a pilot scale covering 1000 ha	Deptt of water resources	2.00	VH	Climate change fund mechanism
5	Undertake study to explore the possibility of Improving water use efficiency in industry <ul style="list-style-type: none"> - Explore possibility of water markets - Through reuse of waste water 	Deptt of Industry	0.50	VH	Climate change fund mechanism
6	Encourage use of recycled water from domestic waste water in urban areas (2 wards in one city)	ULBs	1,00	VH	Climate change fund mechanism
7	Continuous awareness raising on water conservation habits through media	PHE/ULBs	0,10	H	Deptt budget
8	Enable spring shed development in hilly areas to restore the perennial streams within forests (districts close to Nagaland)	Water resources deptt	3.50	VH	Climate change fund mechanism
9	Backyard fisheries in small tanks in same area where water use efficiency will be piloted in agriculture	Fisheries deptt	1.00	VH	Climate change fund mechanism
	TOTAL		10.40		

7.2 Managing Floods

Floods are an annual feature in the Brahmaputra-Barak basin where the maximum flood prone area is of the order of 4.33 million ha. The losses as estimated by GoA due to floods and erosion during 1953-2011 was around INR 4659.472 Cr, with 2,753 and 6,73,329 human lives and cattle lost. The social disruption and costs associated with flooding and the erosion of land have been rising. Besides a large number of towns and villages are affected by the erosive action of rivers.

Over the years, changes in river course of the Brahmaputra has been frequent and continuous; resulting in a large amount of land loss due to riverbank erosion (the average annual loss of land is estimated at around 8,000 ha). Since 1954, erosion has destroyed and removed more than 3800 kms of highly productive farmland, leaving thousands of farmers landless and homeless.

Observed annual trends of peak discharge, example at Pandu (1987 to 2013) and Pagladia (1971 to 2013) along Brahmaputra show a high inter-annual variability but a distinct decreasing trend in the peak discharges across the years is observed (See

Figure 6a and b)²². Continuous braiding and accompanying erosion, the river bed area has expanded significantly from around 3,870 kms estimated between 1916 and 1928, to 6,080 km² in 2006 and continuous load of silt has made the river bed shallow. As a result, even lower peak discharges cause flooding. In addition, flash floods in major tributaries emanating from hills surrounding Assam cause added misery.

Managing erosion and impacts of flooding events are major challenges that the State has to combat annually. Box 1 below briefly describes the steps taken by GoA to mitigate floods.

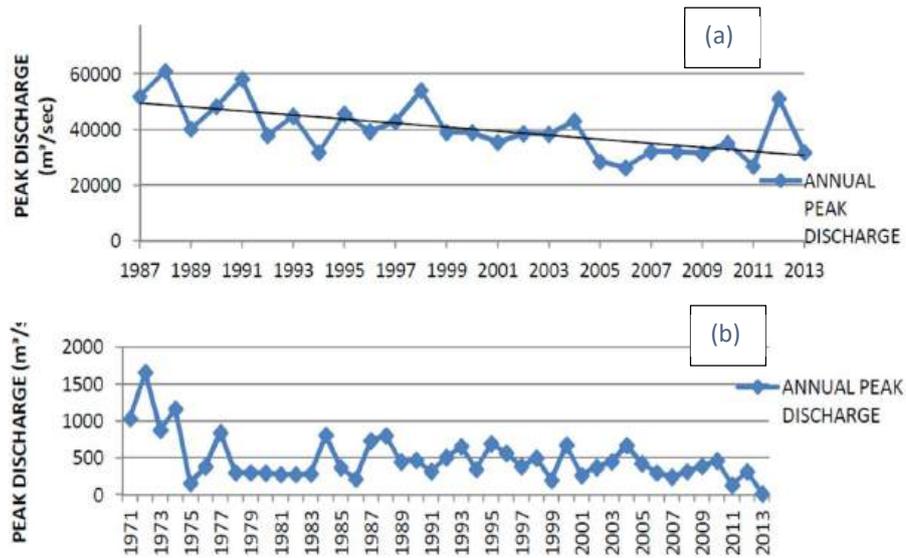


Figure 6: Annual peak discharge for Brahmaputra River from (a) Pandu and (b) Pagladia site¹⁶

²²Homkala Devi and Pankaj Goswami, 2015. Analysis of Climate change on rainfall, temperature and discharge of Brahmaputra, IJIRAE, issue 4, vol 2, April 2015

Box 1: Steps taken to contain and adapt to floods and erosion in the Brahmaputra-Barak river basin

River Bank Stabilisation: Work is under way through an ADB-funded project which is piloting out approaches for river bank stabilization at three specific locations, introducing geotextile material for river bank training.

Maintaining embankments for flood protection: Embankments have been constructed at various points across river banks for flood protection. They often breach, therefore efforts are on to avoid loss of embankments by constructing spurs in some vulnerable location

Studies: Flood modelling study of the Brahmaputra River is being carried out in association with the Friedrich-Schiller University, Jena, Germany.

Flood Early Warning System: FLEWS established in 2008, is an integrated flood warning system that combines actual data and forecasts of rainfall and river water discharge through modelling in association with physical properties of the river system. The IMD, CWC, NEEPCO, Water Resources Department, NESAC and ASDMA together produce the early warning. This has led to reduction in loss of human lives.

Housing: The Mishing community in Assam dwell on the flood plains, and they live in traditional stilt houses called 'chang ghar'. These houses are thatched wood and bamboo houses. The average height of the plinth is six to eight feet above the ground, the height in general conforming to the highest flood level of the area adjudged from long-term observation, and experience of past floods. The base of the house (floor) made of bamboo and wood is adjustable and can be raised to cope with rising flood waters.

Paddy Cultivation: After devastation of the crops and crop land in 2008 floods, alternative cultivating "Boro" paddy for perennially flood-affected areas like Bahpora where mainstream paddy like 'ahu' and 'sali' are difficult to grow because of the floods. With continued success of this cooperative, more and more families are joining the group, making the switch to cultivating 'boro' paddy. In some other areas, such as Majgaon, farmers are doing mixed cultivation of 'ahu' and 'bao' varieties of rice. 'Ahu' can be harvested by the end of May and June, whereas 'bao' ripens in November and December. The logic behind mixed cultivation is that, even if the 'ahu' paddy is damaged by early floods, farmers will still be able harvest the 'bao' rice. In a normal flood year, both varieties can be harvested.

As indicated in the section 4.2, by the mid-century, the heavy precipitation days are likely to dominate and the trend will continue till the end of the century¹⁴. If that is the case, containing floods and avoiding damages will be one of the core areas of expenditure for the State. The State of Assam has formulated the following Strategies to adapt to exacerbated impacts of climate change.

Table 5: Strategies to avert floods in a changing climate scenario

Sl. No	Strategy – Floods	Responsible Agency and time period	Cost (INR Cr)	Priority	Possible Financing Source
1	Detailed scientific study to understand the nature of river flow and its impact on erosion to control erosion in the state of Assam and enable land reclamation	WRD	0.50	VH	
2	Undertaking study to assess intensity and recurrence frequency of floods due to climate change and extent and depth of flooding. In 14 major Urban Agglomerates in the 14 districts prone to floods	WRD	2.8 (@ 0.2 Cr per city)	VH	
3	Develop an integrated flood, erosion and sediment management Action Plan for the Brahmaputra basin 3 major regions in Assam, namely, for Upper, Middle and Lower Assam and drawing upon knowledge on improved technical standards,	Executing Agency: WRD Partners: ASDMA, NESAC, IMD, Research Instt, NGOs	1500.00	VH	World Bank /any other

	global best practices and technologies				
4	Extending River Bank Stabilisation work using geotextile material for river bank training all along the Brahmaputra and Barak river banks.	WRD	750.00	VH	
5	Setting up a North East Hydrology Data Management Centre through basin management approach for managing flash floods.	WRD	2.00	VH	
6	Documenting possible indigenous community based and new adaptation strategies for adapting to floods and implementing the same at pilot scale along with development of fiscal measures for averting climate induced risks.	WRD	5.00	VH	Adaptation Fund
7	Construction of multipurpose flood shelter with inmate capacity of 500 people / Unit in Dhemaji, Lakhimpur, Barpeta; Morigaon & Majuli in Jorhat.	ASDMA	14.00	H	
8	Develop district level management plans to deal with multiple hazards including floods in a changing climate context	ASDMA	8.10	H	
9	Infrastructure strengthening Community based flood early warning system	ASDMA	8.00		
	TOTAL		2282.40		

8. Agriculture

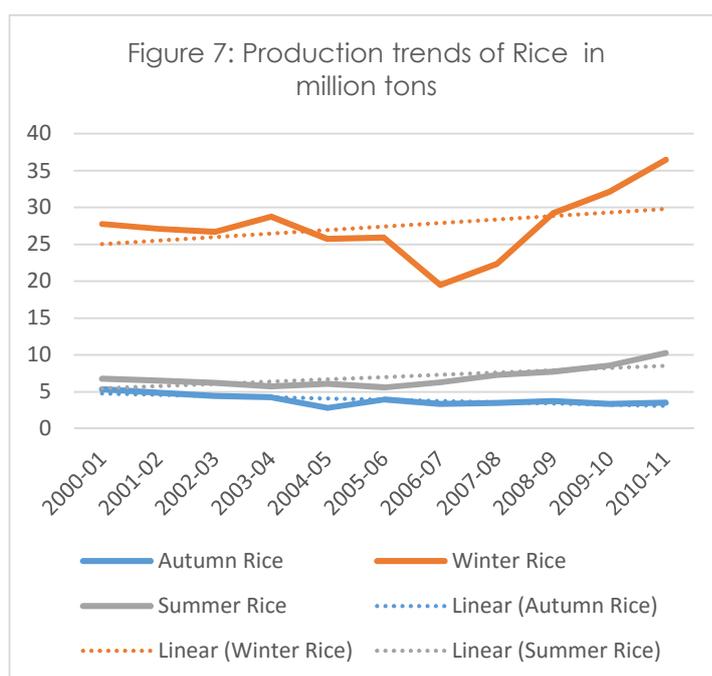
The National Mission for Sustainable Agriculture (NMSA), which is one of the eight Missions under the National Action Plan on Climate Change (NAPCC) seeks to address issues regarding 'Sustainable Agriculture' in the context of risks associated with climate change by devising appropriate adaptation and mitigation strategies for ensuring food security, equitable access to food resources, enhancing livelihood opportunities and contributing to economic stability at the national level.

Assam being an agrarian State lays great emphasis on ensuring the livelihood of its people engaged in agriculture activities. Therefore, integrating climate change adaptation in planning is the key area of thrust for the government. Following the tenets of the National mission for sustainable Agriculture, the Assam SAPCC also focuses on making agriculture climate smart so as to ensure its sustainability and hence livelihoods of the people associated with it.

8.1 Crops

Agriculture plays a vital role in the economy of Assam as 4174023 hectares area is under cropping representing 56.84% of the geographical area of the state²³. The cropping intensity in 2012-13 was 148% percent. Rice, which is the main grain produced in the State, occupied an area of 176432 ha in 2013-14. Rice growing during the kharif season, dominates the agriculture scenario in Assam. Ahu, Sai, and Bao rice were grown in 565, 156.194 and 55 thousand ha respectively. In winters i.e during the Rabi season, Ahu, Sali and Boro rice were grown in 10278 ha, 4844 ha and 4496 ha respectively. 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 include wheat (46 thousand ha), pulses (17 thousand hectares), and maize etc. (45 thousand hectares). The important commercial crops are oilseeds (2005 hectares), sugar cane (3 thousand ha) and jute (66 thousand hectares).

Trends of rice production between 200-01 to 2010-11 (Figure 7), indicates that Autumn rice production in the State has decreased annually at the rate of -3.7%. Whereas the summer and winter rice production have increased at the rates of 3.82 and 5.02 percent respectively²⁴. Winter rice production clearly dominating the total production of rice in the State.



Source: Statistical Handbook- Assam, 2014

Low productivity in many crops due to low seed and varietal replacement rates, deteriorating soil health and ground water; imbalances in agriculture development across districts; post-harvest losses and inadequate processing facilities for fruits and vegetables are some of the very critical problems for the agriculture sector in Assam. The sectors overall growth rate since 2004-05 has been a little over 3.16 percent²⁵, which is below the desired level of 4%²⁶, and therefore 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

²³Statistical Handbook of Assam, 2014. Deptt of Planning, Gov of Assam

²⁴http://www.agriassam.in/agriHorti_profile/Profile%20of%20Agri-Horti%20Sector%20of%20Assam-February%202013.pdf

²⁵Assam Economic Survey, 2014-15. Available at:

http://planassam.info/contents_sub.php?username=&status=&q=25&link_name=25&ID=94&link_caption=Economic%20Survey%20&%20Statistics

²⁶ http://www.agriassam.in/etc/state_agriPolicy.htm

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.

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 increased as measures of assured means of crop production

The challenges that Assam' agricultural sector is likely to face in the future may be anticipated as follows:

Threat to production levels due to rise in ambient temperature: Increase in both frequency and intensity of high temperature, along with its large variability, is emerging as a potential threat to the sustainability of rice production²⁷. This is because rice is a C3 plant and C3 plants growing in hot tropical conditions like in valleys of Assam, photosynthesis becomes inefficient when the temperature rises above long term mean temperatures and deteriorates further when temperature increases beyond this threshold, which is likely to be the case due to global warming.

Reduction in Availability of Water for irrigation: The emerging trends of rain fall indicate that the number of rainy days are decreasing and number and extreme rainfall days are increasing and so is their intensity, with total rainfall increasing in most of the areas in the Assam in the future. It is likely that runoff will be high and as hardly any time will be there for seepage of water into the ground, ground water recharge will go down, therefore extraction of water will be done from deeper levels, making irrigated agriculture vulnerable in Assam. Irrigation is required during summer and in winters. Those are the seasons when rice production is increasing in the State due to availability of assured irrigation (see Figure 6).

Degrading Soil health: 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.

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.

²⁷ Jagadish S V K, K. Sumfleth, G. Howell, E. Redoña, R. Wassmann, and S. Heuer, 2007. Temperature effects on rice: significance and possible adaptation. Available at: http://climaadapt.org/wp-content/uploads/2011/12/Jagadish2007Rice_Impact.pdf

Emergence of new pests and pathogens: Changes in climate 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.

Making Agriculture climate resilient has the potential of uplifting rural poverty and enhancing the adaptive capacity of the sector as a whole. Concerted efforts are required to realize the untapped potential of this sector. Therefore, an integrated adaptation approach is suggested as way forward for ensuring sustainability of agriculture crops and horticulture in the State. The adaptation pathway is indicated in Figure 8 below. Strategies for Adaptation are listed in Table 5.

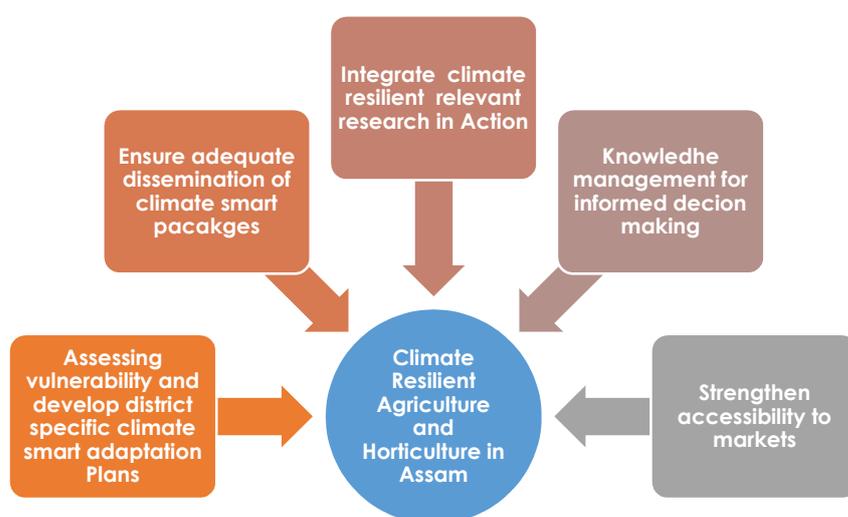


Figure 8: Adaptation Pathway for sustaining agriculture and Horticulture in the State.

Table 5: Strategies for sustainability of agriculture and horticulture systems in a changing climate scenario in Assam

Sl. No	Strategy- Crops	Responsible Agency	Budget (INR Cr)	Priority	Possible Financing Sources
1	Strategy 1: Development district wise climate smart adaptation action plans				
1.1	Assessing District wise exposure and vulnerability of agriculture systems to climate variability and change and developing climate smart Adaptation Strategies through stakeholder consultation for all 27 districts taking into consideration the agro-climatic zone in which they are located	DoA	6.75	VH	

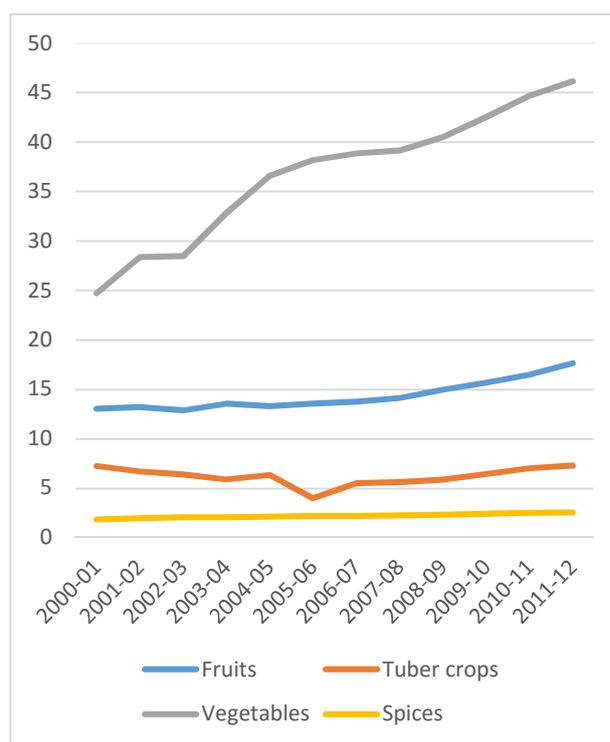
	Total Strategy 1		6.75		
2	Strategy 2: Develop, disseminate, and practice climate smart packages at Pilot scale. Coverage: 90,000 ha	DoA			
2.1	Preparation of DPR through PRA to record phonological variances in crops/plants, soil types, soil and water conditions, new pest host relationships	DoA	0.05		
2.2	Application of climate smart agronomic practices to retain optimum production	DoA	0.15		
2.3	Assessing and broadcasting knowledge on appropriate seed rate, soil moisture conservation activities, water efficient technologies including drip irrigation and tillage operations	DoA	0.10		
2.4	Redefining cropping pattern suitable for each agro-climatic zone	DoA	0.10		
2.5	Establishing demonstrative integrated farming systems by introducing agro-forestry and agro-pastoral practices	DoA	5.00		
2.6	Restore natural water bodies to conserve run off.	DoA	40.00		
2.7	Community vermin-composting	DoA	5.00		
2.8	Expansion of area under low water requirement crops	DoA	5.00		
2.9	Integrated diseases management practices	DoA	5.00		
2.10	Develop and propagate crop specific weather indexed crop insurance	DoA	30.00		
2.11	Train farmers on disaster risk reduction techniques	ASDMA and DoA	0.50		
	Total (Strategy 2):		90.90		
3	Research				
3.1	Developing water and temperature stress tolerant varieties with focus on integrating C4 characteristics in C3 Rice to make photosynthesis efficient at higher temperatures and hence make rice plants temperature and water stress resilient	DoA	0.05		
	Total Strategy 3:	DoA	0.50		
4	Knowledge management, training and skill development	DoA	5.00		
4.1	Automatic weather stations (8 in number) at block level	DoA	17.52		
4.2	Sustainable eco-friendly horticulture in hilly areas	DoA	12.50		
4.3	Computerised weather recording and synthesizing centre	DoA	0.08		
4.4	Establishment of Climate Change Agriculture research Centre	DoA	0.10		
4.5	Training of department functionaries on CC adaptation for developing climate resilient agriculture	DoA	0.10		

4.6	Training of farmers on climate smart packages of practices	DoA	0.15		
4.7	Documenting indigenous knowledge on adaptation for integration with modern techniques	DoA	0.005		
4.8	Publication and dissemination of success stories	DoA	0.005		
4.9	Workshops/seminars on CC resilient agriculture system development	DoA	0.10		
	Total Strategy 4:		35.56		
5.0	Strengthen accessibility to markets				
5.1	Establish market intelligence cell	DoA	1.00		
5.2	Skill development towards producing beneficiated food products (cover 14 districts in Phase 1)	DoA	14.00		
5.3	Establish farmers' companies (village cluster approach in 14 districts)	NABARD	28.00		
5.4	Strengthen cold storage networks (14 districts)	NABARD	14.00		
	Total Strategy 5		57.00		
6	Strategy 6: Protect irrigation schemes from siltation due to soil erosion				
6.1	Plant plantation trees every 25 m on both sides of irrigation canals and reservoirs and beside inspection roads- cover 19244 km	Department Of Irrigation	124.48		
6.2	Install 10 HP pumps sets in irrigation scheme to offset emission from fuel combustion in motors (10 numbers)	Department Of Irrigation	4.00		
	TOTAL AGRICULTURE CROPS		318.74		

8.2 Horticulture

Assam is traditionally rich in horticultural production due to its diverse and unique agro-climatic condition which is conducive for growing wide range of horticultural crops like various fruits, vegetables, flowers, spices nuts tuber crops and medicinal and aromatic plants. The world citrus belt encompasses Assam within it.

Horticultural crops occupy about 15 percent of the gross cultivated area of Assam²⁸ and annually produce more than 70 lakh tons of various horticultural crops such as vegetables, fruits spices and tubers, besides nuts, flowers and medicinal & aromatic plants thus contributing significantly towards food and nutritional security of the State. The compounded annual growth rate of production of fruits, tubers, vegetables and spices has been 2.82%, 0.05%, 5.85% 3.06% respectively between 2001-2011 (See annual production from 2000-2001 to 2010-11 in Figure 9).



Source: http://www.agriassam.in/agriHorti_profile/Profile_ofAgri-HortiSector_ofAssam-June2013.pdf

Horticulture has enormous potential for employment and income generation through commercial exploitation therefore area expansion and raising productivity is the aim of the Government. However, there are some inherent barriers to achieve the full potential and that includes inadequate extension of scientific horticulture technologies, accessibility to packages of input mixes, road communication, marketing, processing and cold storage facilities.

The changing climate introduces additional problems, unless it is taken into consideration in long term agriculture planning of the State, the projected aspiration for this sector is likely to get hampered. Some of the climate change concerns and opportunities are compiled below²⁹

Rising ambient temperatures: Production timing is likely to change due to rise in temperature. Photoperiods may not show much variation. As a result, photosensitive crop will mature faster. As the winter regime and chilling duration will reduce it will affect the temperate crops. Pollination will be affected adversely because of higher temperature. Floral abortions flower and fruit drop will be occurred frequently. Higher temperatures will reduce tuber initiation process in some tuber vegetables, however, in areas at higher altitudes potato production may rise by 5%. Anthocyanin production may be affected in apples and capsicum. Tip burn and blossom end rot

²⁸ Agricultural Statistics at a glance, Government of India, 2012

²⁹ Datta S., 2013. Impact of climate change on Indian Horticulture, International Journal of Science, Environment ISSN 2278-3687 (O) and Technology, Vol. 2, No 4, pp 661– 671.

will be the common phenomenon in tomatoes. The requirement of annual irrigation will increase and heat unit requirement will be achieved in much lesser time.

Diversification to crops that are thermos-tolerant can be encouraged in plains and new varieties that require longer chilling time may move to higher heights.

Heavier precipitation events and floods: This is a concern in the plains as floods devastate horticulture produce. In hilly areas flash floods due to heavy precipitation will lead to heavier soil erosion.

Erratic rains: Unseasonal rains and heavy dew during flowering and fruiting period is likely to aggravate the incidence of pests and diseases.

Long dry periods: This condition would require arrangements that would ensure water for irrigation for horticulture produce, or else horticulture during long dry periods is likely to be jeopardised. The indigenous genetic resources provide a buffer in times of drought, heat and biotic stresses, and genetic resources with bio-alternatives may reduce the vulnerability of production systems to climate change. Additionally, water efficient technologies need to be embraced far and wide.

Table 6: Strategies for sustainable horticulture in a changing climate scenario

Sl. No	Strategy- Horticulture;	Responsible Agency	Budget (INR Cr)	Priority	Source of Funding
1	Sustainable horticulture in hilly areas through plantation crops like cashew nut – Focus: Jhum areas and others. Coverage: 2500 ha.	Directorate of Horticulture Assam	12.50	VH	Horticulture mission
2	Popularisation of indigenous thermal and water stress resistant varieties – black Jamun (<i>Polnia</i>), Sapida (<i>Leteku</i>), Jackfruit, Hog plum (<i>Amara</i>) etc. Coverage: 1000 ha,	-do-	2.50	H	RKVY
3	Growing vegetables in protected condition through Crop diversification and thus facilitating off season production	-do-	4.00	H	Horticulture mission/RKVY
4	Promoting water use efficiency- Construction of water harvesting structures, promotion of drip and sprinkler irrigation: Coverage: 500 ha.	-do-	10.05	VH	Horticulture mission
5	Ensuring soil health – promotion of integrated nutrient management in hilly areas prone to soil erosion: Coverage: 2500 ha.	-do-	1.0	H	Horticulture mission
6	Managing emerging pests and disease management- Integrated pests and disease management. Coverage: 2500 ha	-do-	1.0	VH	

smallholder plots. Large-scale monoculture tea plantations (also called estates or gardens) generally supply commercial cultivation. Contrastingly, local-scale smallholder production is traditionally used to supplement subsistence agriculture and there has been a steady increase in smallholder production for cash crop export in recent years. Tea landscapes play a pivotal role in livelihood security at various global localities e.g. harvesting of tea crops has traditionally been non-mechanised therefore a large labour force is required which provides employment opportunities

Tea is a rain-fed perennial crop. The eco-physiology of tea plants is closely linked to external environmental and climatic factors (elevation, precipitation, temperature, soil moisture, temperature and fertility, light duration and intensity, humidity, shelter, shade and CO₂ concentration) and any adversity in these conditions can significantly impact yield, revenue and livelihood security. The relationship between tea yield and climatic factors implies that long-term climate change will impact the key physiological and developmental processes that determine the yield of tea.

The industry has seen a steady decline in tea production from a high of 0.512 million tons in 2007 to 0.49 million tons in 2010. Thereafter the production has been rising due to addition in small holders' area under tea plantation tea plantation (See Figure 11). The number of tea gardens have jumped from 825 in 2007 to 78856 in 2012.



Figure 11: Tea production trends in Assam in Million tons

Unpredictable rainfall, intense rainfall events, and higher temperatures: The new scientist reports³¹ that erratic rainfall pattern is being observed in the State. It is characterised by too much rainfall, and at times too little. Planters are using sprinklers or irrigation pipes to get better yields. The changes in climate, is bringing in pests such as tea mosquito bugs (*Helopeltis theivora*) which are infesting the plants' shoots. The invaders eat foliage and infect the plants with diseases, thus lowering the yield. The use of pesticides and fertilisers has in turn increased, resulting in an increase in production costs and posing a potential risk to human health.

³¹<https://www.newscientist.com/article/dn27714-climate-change-causing-a-headache-for-assam-tea-growers-in-india/>

Future projections of production due to climate change: Modelling results indicate that tea yields in north-east India are expected to decline by up to 40 per cent by 2050 due to climate change³². As yield is directly associated with revenue, changing climate is also likely to impact economic structures of those reliant on tea, particularly the smallholders given their increased vulnerability to changes in the system. Poverty is a major social challenge in Assam and with the majority of the population reliant on rural livelihoods, socioeconomic changes in the tea industry, driven by changes in enviro-climatic factors, will have a severe adverse impact on livelihood security.

Table 7: Strategies for sustainability tea in a changing climate scenario

Sl. No	Strategy- Horticulture;	Responsible Agency	Budget (INR Cr)	Priority	Source of Funding
1	Real time remote sensing based soil moisture mapping to help in crop planning along with validation at field level; Coverage: All Tea growing areas	Tea Board	5.00	VH	ISRO/Tea Board/
2	Assessing soil carbon across all tea Stations.	Tea Board	5.00	VH	Tea Cess
3	Identifying, procuring and broadcasting thermal and water stress resistant tea varieties,	Tea Board	10.00	VH	Tea Research Station
4	Dissemination of water efficient technologies – sprinkler and drop irrigation Coverage: small holders in 1/4 th of area under small holders	Tea Board	10.00	VH	Tea Cess
5	Creating water harvesting structures for small holders,	Tea Board		VH	Tea Cess
6	Developing pest and disease forecasting systems for tea related pests and planters	Tea Board	0.50	VH	
	TOTAL		30.50		

8.4 Animal Husbandry and Dairying

As elsewhere in India, Animal husbandry is a diversified livelihood option for small and marginal farmers in Assam, and it has a share of 1.77% (P) in the State's GDP. The overall livestock growth rate has declined in Assam between 2007 and 2012 (-0.56%). Amongst bovine stock, the indigenous cattle have registered a growth rate of +2.44%, while crossbred cattle have reduced in the State. The ovine stock comprising of Sheep and goat have registered very high growth rates (above 40%) between 2007 and 2012.

The population of bovine stock comprising of cattle and buffaloes were 10.3 million³³ in 2012 in Assam. Ninety-two percent of these are low milk producing indigenous non-descript type (see Figure 12). The per capita production of milk by indigenous cattle

³²<http://teaclimate.com/climate-change/>

³³Livestock Census, 2012- Assam

in the State is 1.01 litres per day and that of indigenous breed is 2.29 litres per day³⁰. In 2012 Assam produced 8 million tons of milk in 2012. The per capita consumption in the State is less than 1/3rd of the recommendation of ICMR which is 208g/day.

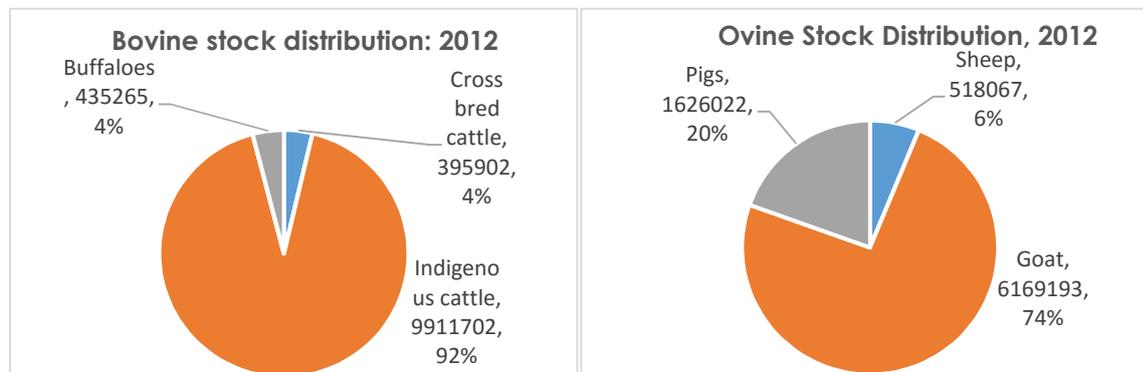


Figure 12: Bovine and Ovine stock distribution in Assam

Source: Livestock Census, 2012, Assam

Cross bred cattle and indigenous buffalo which yield higher milk than the indigenous cattle are only 4% each of the total bovine population in the State. The State has not been successful in propagating cross breeds in the State, as the private artificial insemination workers engaged in remote areas were not successful in generating awareness amongst farmers³⁴. Poor conception rate and marketing are some additional causes of crossbred population not being high in the State³⁵.

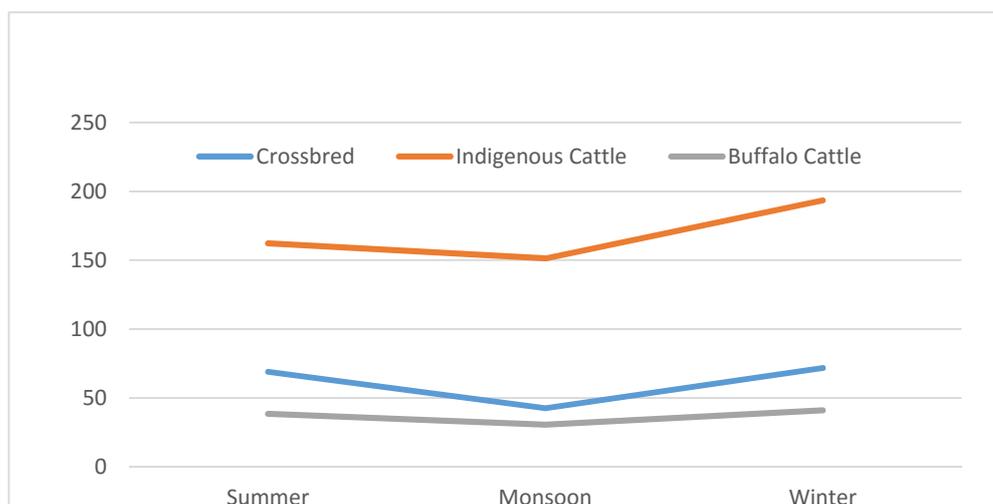


Figure 13: Seasonal Milk production trends (in million litres) across different bovine stock in Assam in 2008-09

Unlike in other parts of India where cooperative farming has revolutionized livestock sector, investment in cooperative farming in the State has remained largely unsuccessful.

³⁴http://planassam.info/Economic_Survey_Assam_2010-11/Economic%20Survey_Chapter-8_LIVESTOCK,%20ANIMAL%20HUSBANDRY%20AND%20DAIRY%20DEVELOPMENT.pdf

³⁵<http://www.vethelplineindia.co.in/veterinary-livestock-sector-development-in-assam/>

Pigs, Goat and Sheep are also an important part of livestock holding here. The population of these two together was registered as 6.69 million in the 2012 census. Pigs are also sought after for their meat and their number stood at 1.63 million in the same year.

Climate Change concerns: Thermal Heat Index, a measure of heat Stress is a function of temperature and relative humidity³⁶. Temperatures in excess of 30-35°C and RH > 50-65% lead to THI>99-110. When THI is just above 72, Livestock starts feeling uncomfortable, leading to decrease in milk production and THI > 85 may lead to fatality³⁷. In Assam average temperatures in the month of June go up to 32°C, when humidity is also high as monsoon sets in. Heat stress conditions get created from summer and it gets more intense during monsoon. As a result, the milk production is maximum during winter and minimum during monsoon (see Figure 12)⁸.

As temperatures are increasing, even at lesser humidity index, the THI indices are likely to intensify further and high THI indices may prevail from post monsoon period. The high THI impact the cross breed milk production drastically. A recent on farm study done by Kohli et al., 2014³⁸ indicate that when THI value exceeded 72, milk production in crossbred cows decreased by 35% to 40% with respect to peak performance period of the stock. In 2013, the temperatures for a few days in June in Guwahati went up beyond 38°C. This also had happened 34 years earlier³⁹. Frequent recurrence of such extreme temperatures due to climate change could lead fatality of livestock.

Another condition known as summer anestrus, whereby, indigenous Buffalos suspend sexual activity and hence milk production⁴⁰. This condition is popularly known as summer anoestrus. The condition is characterized by inactive, smooth ovaries⁴¹, abnormal hormonal profiles⁴². Studies carried out by Upadhaya et al., (2007)⁴³ on Indian Murrah indicates a decrease in milk yield by 15-16% in the summer season from 10.6 Kg/buffalo to 8.8 kg.

Further erratic rainfall patterns that are emerging are also creating conditions for recurrent pests and diseases and new emerging diseases also will have to be tackled in the future.

Adaptation Strategies: 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

³⁶Hahn L G, 1999. Dynamic Response of Cattle to Thermal Heat Loads. Journal of Animal Science, Vol. 51, E. Suppl. 1, (January 1999), pp. 10-20, ISSN 0021-8112

³⁷MoEF, 2011. India's Second National Communication to UNFCCC.

³⁸Kohli S, U. K. Atheya and A. Thapliyal, 2014. Assessment of optimum thermal humidity index for crossbred dairy cows in Dehradun district, Uttarakhand. Veterinary World, EISSN: 2231-0916 Available at: www.veterinaryworld.org/Vol.7/November-2014/3.pdf

³⁹<http://www.ndtv.com/india-news/six-die-in-assam-as-mercury-soars-to-highest-in-33-years-525231>

⁴⁰G K das and FA Khan, 2010. Summer Anoestrus in Buffalo- A review. Reprod Dom Anim 45, c494

⁴¹Roy DT, A R Bhattacharya, and S N Luktuke, 1972. Estrus and ovarian activity of buffaloes in different months. Ind Vet J 49:54060.

⁴²Razdan, M.W., 1988, Buffalo performance in relation to climatic environment. Proceedings of the II World Buffalo Congress, 173-186.

⁴³Upadhyay R. C, S.V. Singh, A. Kumar, S.K. Gupta, Ashutosh, 2007. Impact of climate change on milk production of Murrah Buffalos. Ital.J. Anim. Sci. vol. 6, (Suppl. 2), 1329-1332.

resistant. The milk production in the State can be enhanced by upgrading these indigenous disease resistant and heat resistant varieties with Indian indigenous breeds of cattle and buffalo like Sahiwal and Murrah. Some of the indigenous breeds such as *Bachaur*, *Dangi*, *Kherigarh* and *Siri* varieties of cattle, however, are declining and need conservation⁴⁴.

As buffaloes experience cessation of normal ovarian activity during summer months, therefore for continued uninterrupted reproductive activity throughout the year, breeding of buffalo need to be carried out within the chosen households at right-time based on a standard estrus synchronization protocol. This will further reduce the number of unproductive days in the life-time of a female as well as allow early treatment of shy breeders to minimize their environmental impact. Further, the large livestock population with small and marginal farmers who have difficulty in providing fodder and feed to their livestock can be put up in shelters for enhancing their productivity through sustained veterinary attention and the dung produced can be tapped as a potential source of energy and the nutritionally benefited slurry generated as a part of production of biogas can be used as an organic fertilizer at a large scale. Replacing synthetic fertilizers.

Table 8 below, gives the Strategies that Assam would require to combat rising temperatures and emerging pests and diseases.

Sl. No	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority	Source of Funding
1	Grading up of local cattle and buffalo stock with suitable high milk yielding Indian indigenous varieties such as Murrah/Sahiwal through Artificial Insemination- Cover at least 13 districts Assam, including remote districts	Animal Husbandry	10.00	VH	GoA, ICAR, Multilateral funding
2	Undertake Anoestrus management in buffalos simultaneously in the above chosen districts	Animal Husbandry	10.00	VH	GoA, ICAR, Multilateral funding
3	Creation of gene bank for conservation of threatened breeds (Five)	Animal Husbandry	5.00		
4	Establish scientifically designed community based shelters in 219 blocks to accommodate at least 300 cattle and buffalo of small and marginal farmers- with plantations around for reducing temperature of the surrounding microclimate, and water harvesting structure	Animal Husbandry	21.90	VH	Rashtriya Mission Gokul

⁴⁴Assam Science Society, 2002climate resilient Animal shelters (community base)- with water harvesting

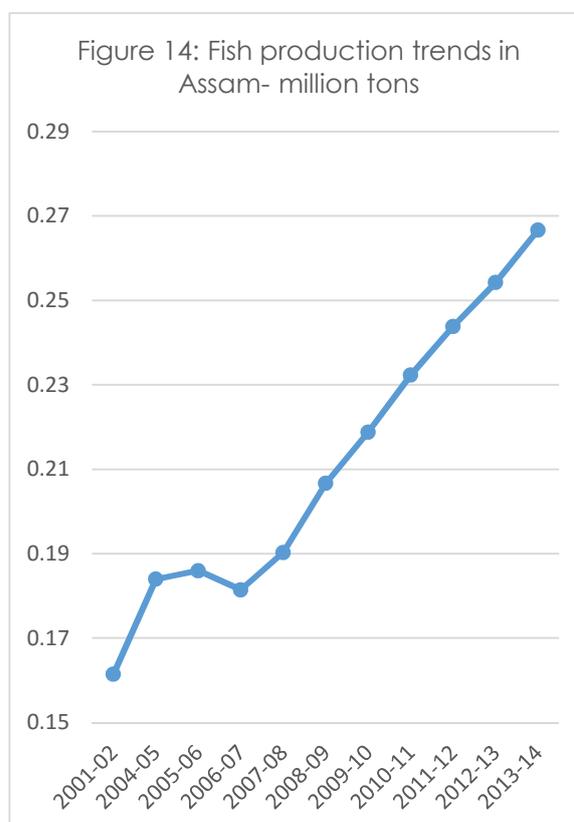
Sl. No	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority	Source of Funding
5	Harness energy from dung collected at community centres- produce 1000 cu m of biogas one in each 219 blocks	Animal Husbandry	219.00	H	Entrepreneur based
4	Undertake fodder cultivation using hydroponic technique- in the shelters in 219 blocks	Animal Husbandry	10.95	VH	ICAR/Entrepreneur
5	Develop and propagate Weather indexed insurance for loss in milk yield due to heat stress. Coverage: All crossbred and genetically upgraded indigenous cattle and buffalo in 219 blocks	Animal Husbandry	5.00	VH	AHD, Insurance company, Any other
6	Develop Disease diagnostic- disease forecasting system	Animal Husbandry	1.00	VH	AHD
7	Disease Management – vaccination, fumigation etc.	Animal Husbandry	233.68	VH	AHD
8	Disease diagnostic (DDL) (Contractual Doctor, TA and other recurring expenses) in 26 districts	Animal Husbandry	78.00	H	AHD
9	Training / capacity building of technical and non-technical person on adaptation to climate change and relevant technologies- 219 blocks	Animal Husbandry	21.90	VH	AHD
10	Safe, quick and effective transfer of milk from producer to chilling plants to avoid spoilage of milk in all 27 districts	Dairy Development	144.20	VH	
11	Establishment of new and refurbishment of existing Milk collection Centres with required technical infrastructure in all 27 districts	Dairy Development	47.70	VH	
12	Setting up of chilling plants to stop bacterial growth at higher temperatures in all 27 districts	Dairy Development	114.80	VH	

Sl. No	Strategy- Livestock	Responsible Department	Budget (INR Cr)	Priority	Source of Funding
13	Capacity Building of Dairy farmers in all 27 districts on <ul style="list-style-type: none"> Scientific dairy cow management Improved milk hygiene and quality Transfer and practice of quality milk production technologies Capacity building of farmers on climate change adaptation 	Dairy Development	31.78	VH	
14	Develop and disseminate package of practices amongst farmers for mitigating disaster risk reduction such as during floods and droughts (in all 27 districts)	Animal husbandry and dairy development	27.00	VH	
TOTAL			10421.10		

8.5 Fisheries

Fish production in Assam is around 0.266 million tons and it is produced from 1.35 lakh ha of water bodies in the State⁴⁵. The fisheries sector comprised of 2.0 percent of the States GDP, employing around 0.5 million populations.

The growth rate in fish production since 2001 has not been dramatic and has hovered around 3.6%. To meet the demand of the fish eating population in Assam, the State imports fish from other States. The imports are reducing over the



⁴⁵Annual Report, 2013-14. Department of Animal Husbandry, Dairying & Fisheries; Ministry of Agriculture, Government of India.

years and in 2013-14 around 13000 tons⁴⁶ were imported. This is much less than previous years due to the fact that domestic production is increasing. However, the per capita consumption is around 9kgs, whereas from nutritional point of view ICAR recommends consumption of 11kg fish per capita.

The State is under utilizing its water bodies and has the potential to produce both warm and cold water fish from 4.77lakh ha of water body cover in the State which are in the form of rivers Brahmaputra and Barak and their tributaries, beels, forest water bodies, derelict water bodies/swamps/low lying areas, reservoirs, household ponds and community tanks.

In Assam, the important riverine fishery of Indian Major Carps has either collapsed or it is at the threshold of collapse⁴⁷. Also there has been drastic depletion in availability of the freshwater ichthyo fauna in north-eastern region due to destruction of the breeding ground, overexploitation and various anthropogenic stresses⁴⁸.

Also the growth of fisheries in the State is affected by Indiscriminate harvesting of fish species from their natural habitat, damage and degradation of river systems due to catchment land use change such as deforestation in the catchment area, river corridor engineering and stream impacts, sand mining, urbanization, tourism, construction of residence on both side of river bank, pollution from industries, agriculture activities, bathing, cloth washing and sewage disposal including open defecation, cultural activities, trapping consumable fishes with pesticides etc. are all are affecting fish production growth in the State^{49,50}. Besides the above factor, overfishing, dynamiting, rampant killing of adult fish, brood fishes, spawn, fry, fingerlings and juveniles are violating Fishery Laws and Act.

Climate change is an additional factor that will be impacting fisheries in the State. Some of the concerns due to climate change are given below, and the Strategies suggested are given in Table 9.

Rising ambient temperatures: Some studies indicate that with ambient temperature rise, oxygen in water will reduce, resulting in reduction of growth and reproduction success of fish and thus reducing their ability to deal with environmental changes. As a result, regime shifts of certain commercial species may happen, which may affect their regional availability and abundance, which in turn will impact the processing sector, either negatively or positively⁵¹.

⁴⁶Assam Economic Survey 2014-15. Directorate of Planning. GoA

⁴⁷Sarma, Pradip Kumar, 2015. Fish Germplasm Diversity and their Conservation Status of River Kaldia in Lower Brahmaputra Valley of Assam, India. *Int. J. Pure App. Biosci.* 2 (6): 46-54. Available at:<http://www.ijpab.com/form/2014%20Volume%202,%20issue%206/IJPAB-2014-2-6-46-54.pdf>

⁴⁸Dutta, A. Choudhury, M. and Acharjee, B., 2007. Natural and anthropogenic hazards in cage and pen aquaculture systems in North-east India. In: *Natural and Anthropogenic Hazards on Fish and Fisheries*. Ed. Umesh C. Goswami, Narendra Publishing House, Delhi. 263-270pp.

⁴⁹ Sharma, S. and Das, B., 2010. Global warming, climate change and its impact on fish diversity of Assam. In: *Proc. Int. Sem. on Climate change, Global warming and NE India: Regional perspectives*, ERD Foundation, Guwahati-29

⁵⁰ Goswami, U.C., Basistha, S.K., Bora, D., Shyamkumar, K., Saikia, B. and Changsan, K., 2012. Fish diversity of North East India, inclusive of the Himalayan and Indo Burma biodiversity hotspots zones: A checklist on their taxonomic status, economic importance, geographical distribution, present status and prevailing threats. *International Journal of Biodiversity and Conservation*,4(15): 592- 613.

⁵¹Vision 2050. Central Institute of Marine Fisheries, ICAR, Min of Agriculture, Gov of India.

Erratic Rainfall pattern and extreme weather events: In the face of climate change erratic rainfall may lead to increased water demand for drinking, agriculture, electricity generation, industry and fisheries. Thus, access and availability of usable water and other ecosystem services is envisioned to be a bone of contention among stakeholders. Events like extreme rainfall and long droughts may bring unforeseen changes to sensitive river systems

Table 9 below, gives the Strategies that Assam would need to embrace to achieve its goals of production of fish in the State in the changing climate context.

Table 9: Strategies for sustaining fish production in Assam in a changing climate context

Sl. No	Strategy	Responsible Department	Budget (INR Cr)	Priority	Source of Funding
1	Creation of up-to-date state level GIS based database on water and fish & fishery resources; water resources and their potential users	Deptt of Fisheries	10.00	VH	State Fund-work to be done by research Instt's
2	Restoration of natural fish breeding and feeding grounds <ul style="list-style-type: none"> - Eviction of illegal encroachment around the natural water resources - Demarcation, de-silting and removal of aquatic weed of beels and their connecting channels 	Deptt of Fisheries	0.10 200.00	H VH	
3	Productivity enhancement and utilization of potential areas <ul style="list-style-type: none"> - Pen/cage culture for production of fish and fish fingerlings - Introduction of re-Circulatory water management system for fish production and short period production system - Fish stock enhancement of the closed natural water bodies with dominant species (10.000 ha) 	Deptt of Fisheries	45.00 25.00 10.00	M M H	
4	Availing Quality fish seed available <ul style="list-style-type: none"> - Brood fish farm, one in each 27 district - Construction of fish seed hatchery (26 no.) - Replenishment of brood fish from brood farms in the hatcheries (100 no.) - Development of seed rearing areas (500 ha) - Strict implementation of legal provisions 	Deptt of Fisheries	2.60 6.00 0.10 0.10 0.10	H L M H VH	

Sl. No	Strategy	Responsible Department	Budget (INR Cr)	Priority	Source of Funding
4	Conservation of indigenous fish species <ul style="list-style-type: none"> - Cataloguing and year wise updating of indigenous aquatic flora and fauna along with conservation Status - Ecosystem based conservation of threatened species and indigenous species and riverine system - Declaring parts of beels as protected areas (1000 beels) - Declaring closed seasons in natural waters - Establishment of State level gene banks in lower, upper, central Assam and in Barak valley (4 nos) - Preparedness/precautionary measures for probable disease outbreak (26 districts) 	Deptt of Fisheries	0.10 1.00 2.00 0.10 0.40 1.30	 VH H M H VH	
5	Reclamation of ponds and beels wherever possible (5000 ha)	Deptt of Fisheries	50.00		
	Rain water Harvesting at HH level for small tank fisheries especially in hilly areas (5000 HH)	Deptt of Fisheries	25.00	H	
6	Developing packages of practices for farmers to sustain their production in a climate change context	Deptt of Fisheries	2.00	VH	
7	Develop and disseminate weather indexed insurance for fisheries sector- to benefit small and marginal farmers and link it to disaster risk reduction	Deptt of Fisheries. ASDMA, Insurance agency	0.50	VH	
8	Community mobilisation for embracing State of the Art package of practices	Deptt of Fisheries	0.60	VH	
9	Establish block level kiosks for fishery related information dissemination including SMS	Deptt of Fisheries	10.05	VH	
10	Climate change Cell in department of Fisheries <ul style="list-style-type: none"> - Will develop road map to deal with CC, - MIS, Data management, - launching studies for strategic knowledge, - developing IEC material, - imparting training for capacity building – staff, farmers; seminars and workshops) 	Deptt of Fisheries	1.77	VH	
	TOTAL		393.82		

9. Forests and Biodiversity

Fortunately, though the dense forest cover in Assam is depleting, but the total forest cover in the State is just above 33% - the National aspiration. The forest cover in Assam extends over an area of 27,671 sq. km. Together with tree cover outside the forests, the total green cover in Assam extends over an area of 253 sq. km which is 37.29% of the total geographical area of the State⁵².

At the same time, Assam is a part of Biodiversity Hotspot exhibiting rich floral and faunal diversity. Apart from an elaborate network of Protected Areas (PA) i.e. National Parks and Sanctuaries, the State also has two World Heritage Sites, a Ramsar Site, two Biosphere Reserve and most importantly, the only thriving population of Asiatic one-horned Rhino in the world.

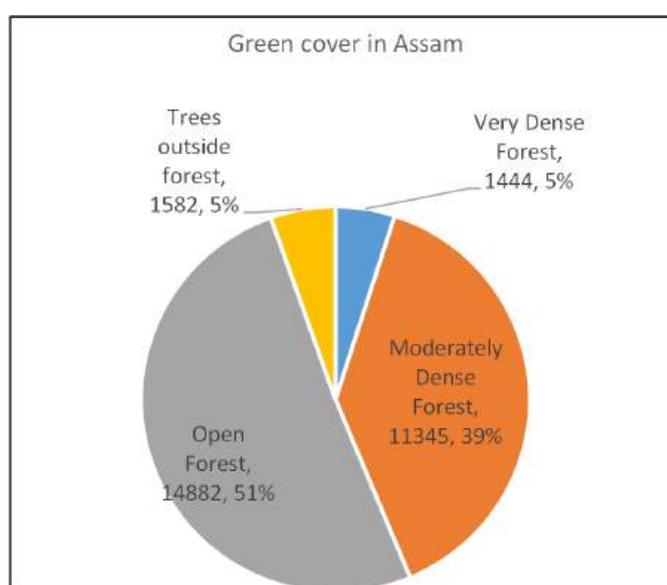


Figure 15: Distribution of Green cover in Assam ⁵²
(In sq. km and percentage of the total)

Apart from providing a variety of products for daily needs, such as, firewood, fodders, medicinal plants, bamboos, fruits, essential oils and so on, the forest also are the recharge zone of rain water in the spring sheds in the mountain areas. Further, they also provide livelihood opportunities to over a million people in the State, who trade in various timber and non-timber products.

Forests are home to very diverse biodiversity, including some very rare, threatened and endemic species. It is believed that several of the commercial crops, such as paddy and lemon originated from wild stock of these forests. A good number of species/varieties of these wild-stock still flourish in Assam.

⁵²FSI, 2013. Status of Forest Report, Forest Survey of India, Ministry of Environment and Forests, Government of India

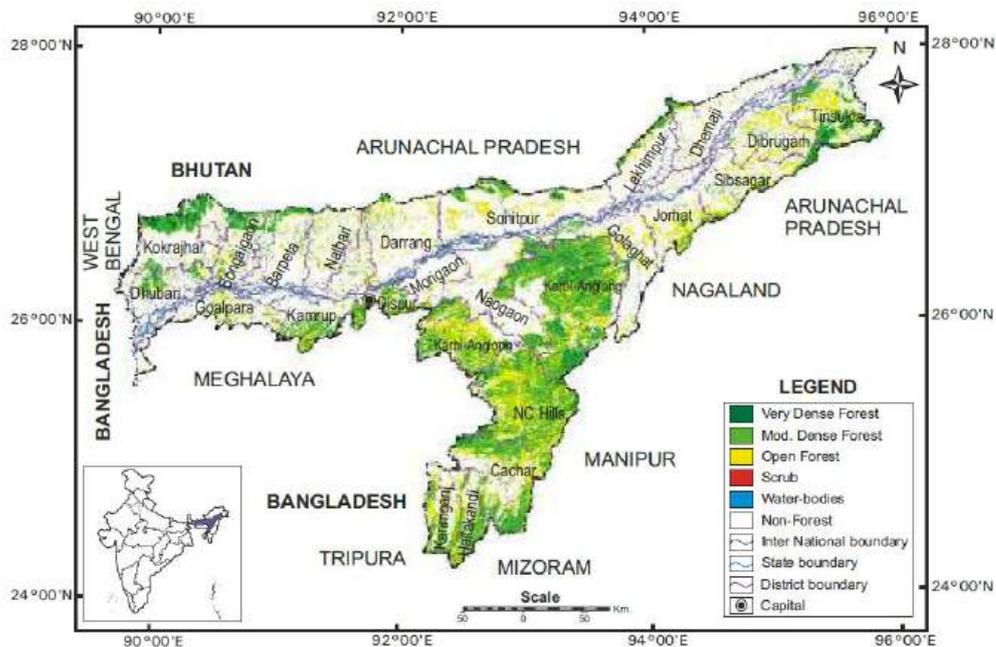


Figure 16: Green cover in Assam⁵²

However, open forests in the State in 2013, as recorded by the Forest Survey of India (FSI) covered 51% (14,882 sq. km) of the total green cover of the State and very dense forests were only 5% of the green cover (see Figure 14). This is because the forest area is suffering from habitat degradation, encroachments, fuel wood extraction etc. This is especially occurring in northern hilly areas bordering Arunachal Pradesh, in the eastern hilly areas bordering Nagaland, and along the south western hilly areas bordering Meghalaya (See Figure 15). This is becoming a double jeopardy for wildlife, their home-range is depleted and conflicts with man are on the rise.

Plantation raised in degraded areas, especially in the Jhum areas, face immense biotic pressures. Cattle grazing and removal of saplings as fodder and fuel pose serious threat to natural as well as assisted regeneration in the forest areas.

Productivity of the forests is rapidly decreasing, thus, eroding sustainability of yield. However, dependencies on forests are on the rise. There is not much diversification in livelihood options for the forest-dwellers or fringe-dwellers.

Model projections: Projections into the future using IBIS model run with climate inputs derived from regional climate model PRECIS with the IPCC A1B scenario⁵³, further point towards increase in vulnerability in 2050s in the areas that are currently vulnerable, i.e. hilly areas bordering Arunachal, Nagaland and Meghalaya⁵⁴. Though uncertainties are associated with these projections, but can be used as indicative directions in which things are likely to move.

Extreme Rainfall in Hilly areas: Extreme rain fall events are likely to lead to heavier run off along the hills, thus the potential ground water recharge in the spring sheds is likely to reduce, along with heavy soil erosion.

⁵³SRES 2010. IPCC Emission Scenarios, 2010. Published by the IPCC.

⁵⁴ N. H. Ravindranath^{1,*}, Sandhya Rao, Nitasha Sharma, Malini Nair, Ranjith Gopalakrishnan, Ananya S. Rao, Sumedha Malaviya, Rakesh Tiwari, Anitha Sagadevan, Madhushree Munsji, Niharika Krishna¹ and Govindasamy Bala; 2011. Climate Change Vulnerability Profile for the North East India. Current Science, Vol 101, no 3, pp384 to 394.

Longer Dry periods: With longer drought periods, biodiversity- both floral and faunal are likely to be affected and forest fires may become the norm, with increasing man-animal conflict. Thus affecting the various types of timber and NTFP produce and hence the livelihood of the people dependent on the same.

This situation calls for anticipatory actions beyond the business-as-usual approach. The Forestry component of the State Action Plan for Climate Change (SAPCC) has been so designed as to effectively mitigate climatic changes and adapt to new situations, for maintaining a healthy and productive human-environment interface. Keeping in view the Green India mission and the vulnerability of the State, the strategies thus focus on:

1. Reducing Degradation and Deforestation;
2. Improving carbon sequestering capacities of forests by
3. Improving resilience of wildlife
4. Empowering local communities to take charge and benefit from biological diversity
5. Improving adaptability of forestry-ecosystems and dependent communities through research, innovations and use of appropriate technologies

This is in line with the Green India mission, which aims to protect, restore and enhance India depleting forest resources through increase forest/tree cover; improve/enhance eco-system services like carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; along with provisioning services like fuel, fodder, and timber and non-timber forest produces (NTFPs); and increase forest based livelihood income of about 3 million households.

Table 10: Strategies for sustaining Forests and the ecosystem produce from forests in Assam

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
1	Reducing degradation of forests by closure of areas with promising regeneration and root-stock of natural species (Secured ANR); 4000 ha	Deptt of Forests	70.00	VH	GiM/
2	Improving density of cover in degraded forest areas <ul style="list-style-type: none"> - Open forests (artificial regeneration with fencing); 200 blocks of 25 ha each - Moderately dense forests; 5000 ha 	Deptt of Forests	120.00 62.50	H M	GiM/ CAMPA APFBC / GiM

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
3	Safeguarding against encroachment in RFs and PAs RFs <ul style="list-style-type: none"> - Highly sensitive areas (Inter-State borders / City RFs); 2,00,000 RM - Other sensitive areas; 2,00,000 RM PAs <ul style="list-style-type: none"> - Highly sensitive areas (Inter-State borders); 50,000 RM - Other sensitive areas; 1,00,000 RM 	Deptt of Forests	170.00 170.00 42.50 85.00	VH H VH H	GoI / Fin. Comm. GoI CAMPA CAMPA
4.	Building climate resilience of forest based livelihoods <ul style="list-style-type: none"> - NTFP focused forest management to help forest- dependent communities adapt to CC through emphasis on multiple utility species; 1000 ha - Developing Nurseries for providing quality planting material including that of Bamboo/ indigenous Fruit trees / Medicinal Plants and other multi-utility trees; 35 nurseries of 1.5 ha each - Promotion of Agro-forestry for improving livelihood: Bamboo / Fruit Trees / Medicinal Plants; 1000 ha - Skill Development of Forests communities in sunrise sectors for reducing pressure on forests; 1 lakh beneficiaries 	Deptt of Forests	5.00 3.50 12.50 300.00	H H VH H	GiM GiM APFBC GiM / APFBC

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
5	Promoting alternate sources of energy for wood substitution as fuel. <ul style="list-style-type: none"> - Energy plantations; 1500 ha - Solar Plants (8KVX3; 5 KVX5; 3 KV X10); 35 units - Bio-gas plants; 400 	Deptt of Forests	7.50 2.00 1.00	VH M M	GiM / APFBC GiM / Colateral GiM / Colateral
6	Providing LPG connectivity to Forest Villagers and to fringe dwellers reducing fuel-wood dependencies; 5000	Deptt of Forests	5.00	H	APFBC/ Colateral
7	Securing identified wildlife corridors and improving their habitat status by compensating the communities for conservation; 2500	Deptt of Forests	125.00	VH	GiM
8	Procuring crucial areas surrounding Protected Areas for extended protection to threatened and endangered species (e.g. various additions to the Kaziranga NP); 300 sq. km	Deptt of Forests	600.00	VH	GiM
9	Improving Protected Area Management <ul style="list-style-type: none"> - Control and eradication of Invasive species - Enrichment planting, 200 - Micro-ecosystem improvement; 1000 (wetlands/ grasslands/ breeding grounds etc), 20 projects 	Deptt of Forests	5.00 5.00 5.00	VH H H	GiM / APFBC Gim/ APFBC Gim/ APFBC/ Gol
10	Intensive Management of Wetlands for achieving <ul style="list-style-type: none"> - Conservation of wetland biodiversity - Recharge of ground water (20) - Collateral benefits to communities (Eco-tourism) 	Deptt of Forests	5.00 2.00 -	H H H	Gim/ APFBC/ Gol Gim/ APFBC/ Gol Gim/ APFBC/ Gol

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
11	Creating Gene Banks (Ex-situ) <ul style="list-style-type: none"> - Conservation for Biodiversity of the State / Specimen Lab / Herbarium/Multi-location repositories of germplasm 2 central facilities and 35 site banks 	Deptt of Forests	11.50	M	GiM
12	Strengthening Biodiversity Conservation Institutional Mechanism - State Biodiversity Board <ul style="list-style-type: none"> - Mobilizing Community and developing peoples Biodiversity Registers for documenting local bio-resource diversity and associated traditional knowledge - strengthening of Biodiversity Management Committees (200 BMCs) - Awareness Generation amongst stakeholders - Documentary/TV Show/ Theatre / Workshops) 	Deptt of Forests	6.00	H	GiM / GoA / NBA/APFBC
			3.00	H	GiM/ NBA/ GoA
13	Conserving biodiversity in a changing climate scenario <ul style="list-style-type: none"> - Developing State Biodiversity Strategy & Action Plan and BMC Management Plans - Biodiversity Inventory and documentation with inputs on present conservation needs - Assessment of past management practices / biotic pressures / CC for developing new strategies - Species based research on 	Deptt of Forests	0.05	VH	APFBC/
			10.00	VH	GiM/ NBA
			0.05	H	GiM
			25.00	M	GiM / GoA

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
	conservation needs, strategies and conservation actions				
14	Improving Tree cover outside Forest areas: Avenue, city forests, Panchayat Forests, Homestead, Gardens, Parks, Institutional lands etc	Deptt of Forests	100	H	GiM
15	Plantation on special / difficult sites: <i>Jhoom</i> lands for soil conservation and in <i>Char</i> areas (river islands) for preventing erosion of banks during heavy floods <ul style="list-style-type: none"> - Plantations / Protection - -Community participation in rehabilitation 	Deptt of Forests	20 5	H H	GiM GiM
16	Protection against Forest Fires specially in Hill areas <ul style="list-style-type: none"> - Central Monitoring Unit/Field (2 central units) - Stations/Field gears (20 field stations) 	Deptt of Forests	20	VH	SSS/CAMPA/CSS
17	Integrating criteria and indicators of SFM into Working Plans	Deptt of Forests	6	VH	GiM
18	Commissioning of Preservation Plots: studies into change in vegetation is response to CC – genetic resource preservation	Deptt of Forests	5	H	GiM
19	Pilot Studies on Carbon stocking in forests: establish the protocol for measuring, reporting and verification systems for forest carbon.	Deptt of Forests	10	H	GiM
20	Vulnerability Study of Forest Ecology to Climate Change including assessment of changes in Forest Types / sub-types	Deptt of Forests	100	H	GiM
21	Policy Review / Developing Policy: State Forest Policy, Bamboo & Cane Policy, Wetland Policy, Eco-tourism Policy	Deptt of Forests	5	VH	GiM /APFBC
22	Linking of Micro-plans with Working Plans	Deptt of Forests	5	H	GiM

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
23	Reducing carbon footprints of forestry infrastructure - Eco-friendly buildings/gadgets etc; 800	Deptt of Forests	960	H	GiM/CAMPA
24	Develop a Manual for disaster risk reduction vis-a-vis for averting - landslides in forests - for averting forest fires - for avoiding mortality of wildlife during floods	ASDMA & Deptt of Forests	0.50	VH	CAMPA
TOTAL			19826.50		

8. Habitats

As per Census 2011, 86% of Assam's population lives in 26395 villages as compared to only 14% that are spread across its 214 towns⁵⁵. Other than Assam, Bihar and Odisha are the only two other Indian States, who have less than 20% of their total population living in urban spaces now⁵⁶. At all India level, 68.84% of the India's population lives in rural areas and 31.16% in cities⁵². Like elsewhere, the decadal growth rate of rural population in Assam is declining. It has decreased from 17.29% in 2001 to 15.23% in 2011.

Around 4.3 million of Assam's population lives in cities⁵⁷. The urban population growth rate has risen from 12.72% in 2001 to 14% in 2011⁵⁸. Guwahati, Nagaon, Dibrugarh and Silchar spread across length and breadth of Assam are the most prominent cities (see the locations in the figure alongside). Guwahati is the largest Urban agglomerate with a population of 0.9 million.



Figure 17: Location of 13 prominent cities in Assam

As the population is rising in urban areas, multiple challenges related to the following are likely to be encountered

⁵⁵http://ecostatassam.nic.in/ads_assam%20at_glance.pdf

⁵⁶<http://www.nird.org.in/Rural%20Development%20Statistics%202011-12/data/section-1.pdf>

⁵⁷http://tcpassam.gov.in/urbanisation_last_decade.pdf

⁵⁸Census of India 2011

- solid waste management,
- sewerage disposal,
- drinking water availability,
- adequate transportation and
- Managing Human Health

In the present context examination of public service delivery in the most prominent 13 cities in Assam indicates that the public service delivery of the water supply, sewage disposal and Solid waste management (SWM) coverage is lower than the National average (see Table 11).

Table 11: Urban service delivery performance in 13 largest towns in Assam⁵⁹

	Surface water supply coverage (%)	Per capita surface water supply (lpcd)	Hours of surface water supply (hpcd)	Metered connection (%)	Sewerage connection (%)	SWM coverage (%)	Sanitary landfill disposal (%)
National targets	94-100	135	24	100	70-100	Na	100
National average	81	123	4	25	28	78	2
State Status (median of 13 towns)	32	55	2	0	0	56	0
Guwahati	30	80	2	5	0	85	10
Dibrugarh	15	50	1	0	0	70	0

8.1 Water Supply

Currently, a "Tropical Monsoon Rainforest Climate" prevails in Assam, with average summer max. at 35–39 °C and winter min. at 5–8 °C with heavy rainfall and high humidity during monsoon. Spring (Mar–Apr) and autumn (Sept–Oct) are usually pleasant with moderate rainfall and temperature. This situation provides Assam with adequate water for all purpose including drinking water.

There are numerous sources of drinking water (see Figure 18below) in Assam, but they are minimum in Karbi Anglong and in further down south. Though the sources look many, but water supply infrastructure is certainly inadequate as inferred from Table 10.

⁵⁹ADB 2011. Propose multi-tranche Financing Facility India: Assam Urban Infrastructure Investment Program. Report and Recommendation of the President to the Board of Directors. Project number 42265.

Therefore, augmentation and minimizing evapotranspiration is a key strategy for ensuring availability of potable water. In case of Assam, addressing water shortages and water contamination during floods is another area of concern. The 3rd might be reviewing all water harvesting structures and aligning their structure and water supply operations with projected climate change. Next strategy can be to promote water use efficiency through various methods. These strategies are outlined in Table 11.

These concerns have been raised in the mission on Sustainable Habitats which is a part of the National Action Plan on Climate Change India's. The mission aims to promote energy efficiency as a core component of urban planning, the plan calls for Extending the existing Energy Conservation Building Code; A greater emphasis on urban waste management and recycling, including power production from waste; Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles; and Incentives for the use of public transportation. Additionally, we believe that urban spaces are vulnerable to climate change as is the human health. These together therefore form the core areas where strategies have been suggested to build resilience to Climate change (see Table 12).

Table 12: Strategies to address climate change impacts for sustainable water availability – potable and for agriculture

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
1	Ensuring water availability in a changing climate scenario				
	Roof top rain water harvesting; 2500 numbers (in southern Assam cities)	PHE	53.75	H	JNNURM
	Check dam, 30 numbers (in Southern Assam cities)	PHE	3.00	M	
	Pond HRF (horizontal roughing Filter-Geo membrane line masonry); 50 numbers	PHE	0.75	M	
2	Ensuring potable water during floods				
	Board mounted WTP (water treatment plants) for flood effected areas; 5 numbers	PHE	5.00	M	
	Speed boat for distribution of WATSAN material during climate change induced floods	PHE	2.50	M	
3	Facilitating ground water recharge even in extreme rainfall condition				
	Artificial recharge with pit/trench; 4000 numbers	PHE	40.00	VH	
4.	Enhance water use efficiency				

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
	Metering of water supply connections in at least 13 major cities- to cover at least 5 cities in 5 years	PHE	100.00	VH	Loan
5	Increasing solar energy penetration and reducing load on conventional source				
	Solar pumping in PWSS; 2000 numbers	PHE	200.00	VH	Solar mission
	Solar lighting in Head office	PHE	4.25	H	Solar mission
6	Research			H	
	Assessing risk due to climate change and designing required Infrastructure and System Operation for water supply systems in one key city in Assam	PHE	1.00	VH	Bilateral funding/ Multi-lateral funding
7	Capacity building				
	Developing capacity of government officials towards assessing the vulnerability of water resources in their districts and drafting strategies for ensuring water availability (for all 27 districts) and disaster risk reduction	PHE and ASDMA	1.00	VH	Bilateral/Multilateral funding
	Training and skill development of Govt. functionaries on climate change resilient WATSAN system	PHE	0.30	H	Bilateral/Multilateral Funding
	Exposure visit of Govt. functionaries on climate change resilient WATSAN system	PHE	0.50	H	Bilateral/Multilateral funding
	TOTAL		412.05		

8.2 Municipal Waste Management and Sewage treatment in cities

Considering that 4.3 million people live in urban areas in Assam⁶¹ and they produce on an average 300 tons of solid waste per day⁶², the annual solid waste generated is around 471 Giga tons. Though door to door collection of MSW has been introduced in some cities in Assam but still scientific treatment and management of solid waste is not the norm everywhere. India's first integrated waste management is being implemented in Guwahati, where the facility would develop mechanisms for waste collection, segregation, recycling and improved solid waste collection, transportation, treatment, disposal and energy generation. However, as the pace of the population pressure increases in urban areas, development of MSW management infrastructure development has to be speeded up, as unscientific management of MSW leads to many issues.

Unscientific management of solid waste may lead to ground water contamination by the leachate generated by the waste dump; surface water contamination by the run-off from the waste dump; bad odor, pests, rodents and wind-blown litter in and around the waste dump; generation of inflammable gas (e.g. methane) within the waste dump; bird menace above the waste dump which affects flight of aircraft if the dump areas are nearby the airports; fires within the waste dump leading to emission of toxic materials; erosion and stability problems relating to slopes of the waste dump; epidemics through stray animals; acidity to surrounding soil; and release of greenhouse gases. These are likely to escalate in the future as more and more population moves into the urban spaces, unless arrangements are made to avoid the situation.

Domestic waste water constitutes of human excreta, urine and the associated sludge, (collectively known as black water), and waste water generated through bathing and kitchen (collectively known as grey water)⁶³. Untreated waste water percolates

Box 3: Current scenario in Tezpur Solid waste management System

India's first integrated solid waste management project was planned at Boragaon, Kamrup for the city of Guwahati. The Boragaon disposal and processing site is in Kamrup district, northwest of Guwahati and 12 km away from the city centre. GMC has got approved a grant of around Rs 35 crore for the project under the Centre's JNNURM scheme.

The project envisaged undertaking entire cycle of waste collection to power generation. The project costing around Rs 102 crore will be implemented on BOOT basis under a 20-year concession agreement. This involves entire waste cycle management, including primary (door-to-door) collection of municipal solid waste, transportation of MSW to the processing site and processing/disposal of MSW. The last aspect would include setting up a 650-tonne per day plant to convert MSW into refuse derived fuel (RDF), a compost plant of 50 tpd to produce manure and a 6-mw power plant, the electricity from which be supplied to Assam gov.

So far 40 acres has been handed over and the remaining would be transferred in due course. The municipal corporation has floated a special purpose vehicle, Guwahati Waste Management Company Pvt. Ltd, for the project. Infrastructure Development Corporation of Assam Ltd, a joint venture between Guwahati Metropolitan Development Authority and IL&FS, is acting as project management consultant.

However, the project has not started. Instead recycling of HH waste is being practiced within some wards of Guwahati at HH level.

⁶¹Census 2011

⁶² Based on "Manual on Solid Waste Management" prepared by Central Public Health & Environment Engineering Organization (CPHEEO), Ministry of Urban Development, Govt. of India.

⁶³http://cpcbenvvis.nic.in/cpcb_newsletter/sewagepollution.pdf

into the soil and goes into water streams, ponds and rivers, as a result of which it poses a huge public health problem. In Assam, management of domestic waste water (sewerage) is absent in the State (See Table 11). Per capita waste generation in India is estimated to be 121 liters/capita/day⁵⁹. Considering that the urban population in Assam is around 4.3 million, the urban Assam produces around 189910 million liters of domestic waste water. Even if the population rises in a business as usual scenario, at the end of the next 10 years, the waste water generation is likely to be at least 1.14 times more than what is generated now. Without creating waste water treatment facilities, the public health problem can become a menace.

Some of the Strategies suggested to ensure solid waste management and waste water treatment in the State, at least in the urban space are as follows:

Table 13: Strategies to ensure waste water treatment and solid waste management within urban habitats impacted by climate change

Sl. No	Action	Department Responsible	Costs (INR CR)	Priority	Sources of Fund
1	Wastewater treatment				
	Community Waste Management System in peri-urban areas (approx. 4 nos in each block)-1000 in number	PHE	0.20	VH	JNNURM
	Trailer mounted community Bio-toilet for areas affected with climate change resulted flood- 45 in number	PHE	0.32	VH	JNNURM
	Colony based sewage treatment plants- recycled waste water will be used for parks, gardens and other uses in all cities (at least cover 2 cities in 1 st 5 years)- 60 in number	Department of Urban development	2.00	VVH	JNNURM
2	Solid waste management				
	Feasibility studies in 14 major cities in Assam, excluding Guwahati for setting up integrated waste management plants	Department of Urban Development	1.00	VH	JNNURM
	Feasibility study to set up cluster based MSW management amongst class II and III tier cities in Assam	-do-	2.00	VH	JNNURM
	Undertake -MSW management -de-silting of drains -sewage treatment In flood prone cities in Assam spread along 14 districts along the banks of Brahmaputra. Cover 2 cities in the 1 st 5 yrs.	-do-	720.00	VVH	JNNURM
	TOTAL		725.00		

Also most of the cities and townships in Assam do not 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.

8.3 Road Transport

Rapid increase of numbers of motor vehicles on road in Assam has been observed over the past decade. The on road vehicle population in the State reached 1.98 million in 2013-14 from 0.53 million in 2001-01 (see Figure 19). The growth has been at a compounded annual growth rate of 12.7%. The number of Motor vehicles registered in the State is 6360 per lakh of population.

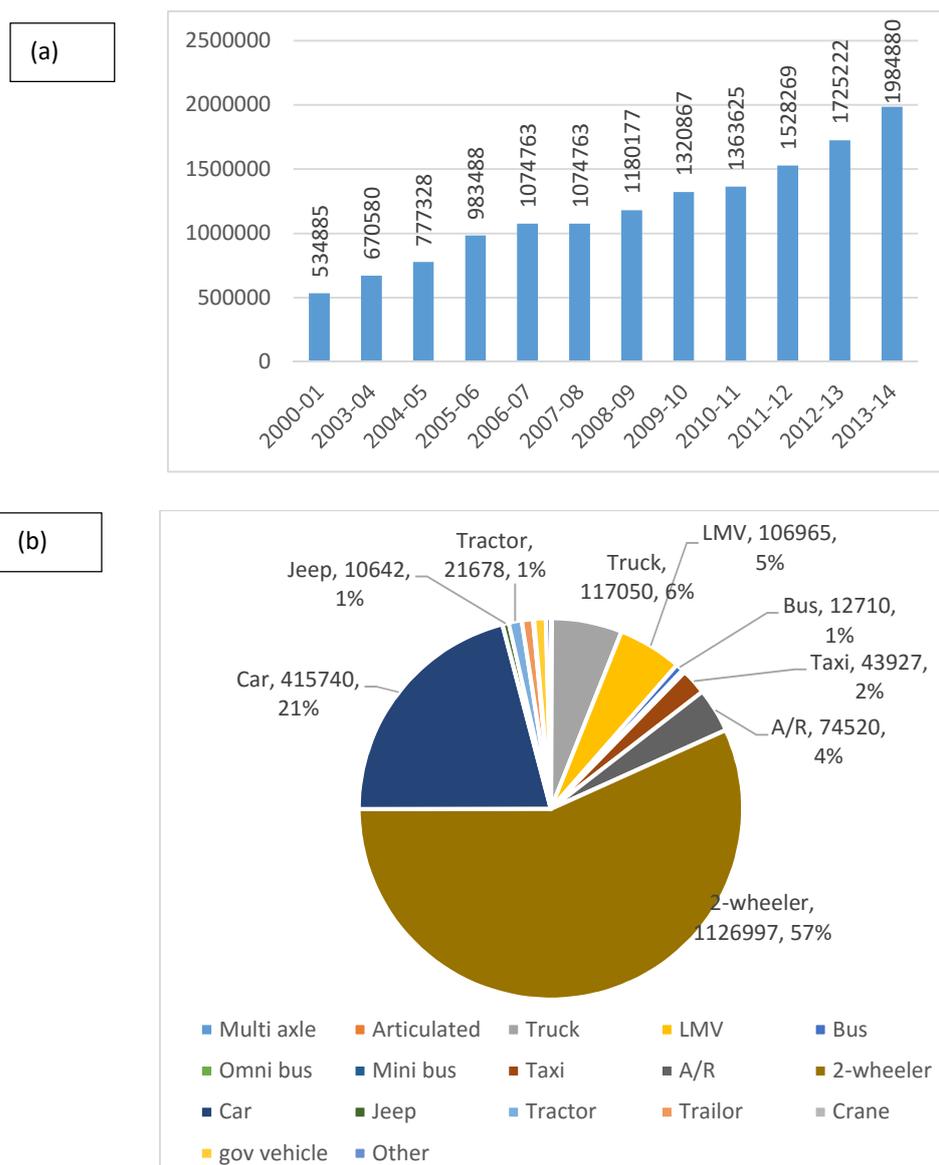


Figure 19: (a) Trends of growth of road vehicles in Assam, (b) Vehicle mix in 2013-14
 Source: Office of the commissioner of Transport, Assam and Directorate of Economics and Statistics, Assam.

Due to lack of adequate public transport system where buses comprise of only 1% of the total population of vehicles on road, and due to availability of easy loans, most of

the people are aspiring to buy their own vehicles. As a result, two wheelers are 57% of the total vehicle mix in the State, and cars follow suit with a 21% share in 2013-14.

The road transport sector being a direct consumer of fossil fuel, emits GHG into the atmosphere. With increase in population and per capita rise in number of personal vehicles, GHG emissions are likely to rise. Use of public transport system need to control future emissions in the future and also to ease off the pressure of vehicles on the roads, hence. This would require policy changes in the way lending is done by banks, enabling fuel mix with biofuels, and also behavioral changes of the population whereby they use more and more non-motorized transport at short distances and public transport for long distances. The Guwahati city is already in the process of developing the Bus Rapid Transit System (BRTS), but further development of the public transport system is required. Other major cities also need to embrace the same for an orderly functioning road transportation system in the cities of Assam.

The roads and bridges built for the transport sector are also susceptible to floods and landslides in the State, the intensity of which is likely to increase in the future. In this context therefore roads, bridges need to be built keeping in view the maximum projected intensity of extreme events.

Table 14: Suggested Strategies for the transport sector

Sl No	Action	Cost (INR Cr)	Sources of Fund	Priority	Department Responsible
1	Installation of CNG pump stations across major cities of Assam; 100 depots	25.00	Franchisee/Vendor Funded	VH	Department of Transport
2	Procurement of CNG enable buses, 1000 buses	250.00	JNNURM	VH	Department of Transport
3	Assess requirement of non-motorized transport numbers and Introduce tracks for non-motorized transport along existing roads, 10 major cities	2.00	State Govt./Central Govt.	H	Department of Transport
4	Retrofitting all Public Vehicles with CNG Kit – Policy regulations to be formulated	100.00	State Govt./Central Govt.	VH	Department of Transport
5	Introducing intelligent traffic management systems, 10 major cities	10.00	State Govt./Central Govt.	H	Department of Transport
6	Construct parking slots in Guwahati, Tinsukia, Dibrugarh, Nagaon, Tezpur, Jorhat and Silchar. Partial cost of construction, 7 major cities	35.00	State Govt./Central Govt.	H	Department of Transport
7	Promote better driving practices and maintenance of vehicles among truck, bus and car drivers to enhance fuel efficiency	1.00	State Govt./Central Govt.	H	Department of Transport
8	Study on BRT for 7 major cities other than Guwahati where BRT is already planned	0.50	State Govt./Central Govt.	H	Department of Transport

9	Vulnerability assessment study of transport system of Guwahati and other important cities due to climate change	0.50	State Govt./Central Govt.	VH	Department of Transport
10	Developing manual for building climate resilient roads and bridges and train engineers on retrofitting old ones and new designs (all Districts)	14.00	State Govt./Central Govt.	VH	Department of Urban development
	TOTAL	438.00			

8.4. Inland Water Transport

Assam is a riverine state. As much as 32 percent of the water resource of the country flow down through the river Brahmaputra, Barak and their myriad tributaries that weave a vast network of waterways in the State. The Brahmaputra has 891 Km navigable length of water ways from Sadiya to Dhubri while the Barak has 94 Km length of navigable waterways. The Sadiya – Dhubri stretch of the Brahmaputra River has been declared as the 2nd National waterways of the country in the year 1988 and afterwards the proposals to activate the Commercial service have been moved for overall economic development of the North-eastern Region. Barak also has been declared as the 6th National water ways of the country. Currently, the Directorate of Inland Water Transport is operating more than 200 ferry services under IWT Divisions on the river Barak, Brahmaputra and its tributaries for the purpose of public utility, goods transport and other miscellaneous connecting remote corners of the State and is used for international trade as well.

The water ways thus also are a source of GHG emissions. As passenger transport and goods transport are relying more and more on water transport, the ferry services are likely to increases. Spillage of fuel also a common phenomenon which affects the aquatic life in the rivers. Keeping this in view it is proposed that the vessels need to go green. In this respect the strategies proposed are:

Table 15: Strategies for Water ways

Sl. no	Action	Costs (INR Cr)	Source of Fund	Priority	Department Responsible
1.	The IWT vessels rely on fuel oils for most powering needs, but tighter emission regulations and the need to 'go green' and hence conversion of existing Diesel Marine Engines to CNG driven engines proposed. (40 engines in 20 vehicles)	10.00	JJNURM/ IWT/Any other	H	Inland Water Transport Department
2.	Solar powered passenger vessel in 10 vehicles	100.00	IWT	H	Inland Water Transport Department
3	CNG Filling Station (Phase: I – Guwahati-02) (Phase: II- all over Assam-04)	10.00 10.00	IWT	H M	Inland Water Transport Department

4	Conversion of existing engines of IWT Vessels to CNG, 40 vessels	10.00	IWT	M	Inland Water Transport Department
	TOTAL	140.00			

8.5 Human Health

The health of human populations is sensitive to shifts in weather patterns and other aspects of climate change. These effects occur directly, due to changes in temperature and precipitation and occurrence of heat waves, floods, droughts, and fires. Indirectly, health may be damaged by ecological disruptions brought on by climate change (crop failures, shifting patterns of disease vectors), or social responses to climate change (such as displacement of populations following prolonged drought). Variability in temperatures is a risk factor in its own right, over and above the influence of average temperatures on heat-related deaths. Biological and social adaptation is more difficult in a highly variable climate than one that is more stable.

Assam having an undulating physiography, moist tropical climate is endemic to malaria. Malaria incidences reported in the state go up to many other climate related diseases are being routinely reported despite control measures being taken. Some of the other diseases occurring at a large scale i.e. incidences reported in excess of 30,000 include Acute Respiratory Infection (ARI) and influenza, Pyrexia related to ticks, Japanese Encephalitis (see Figure 20).

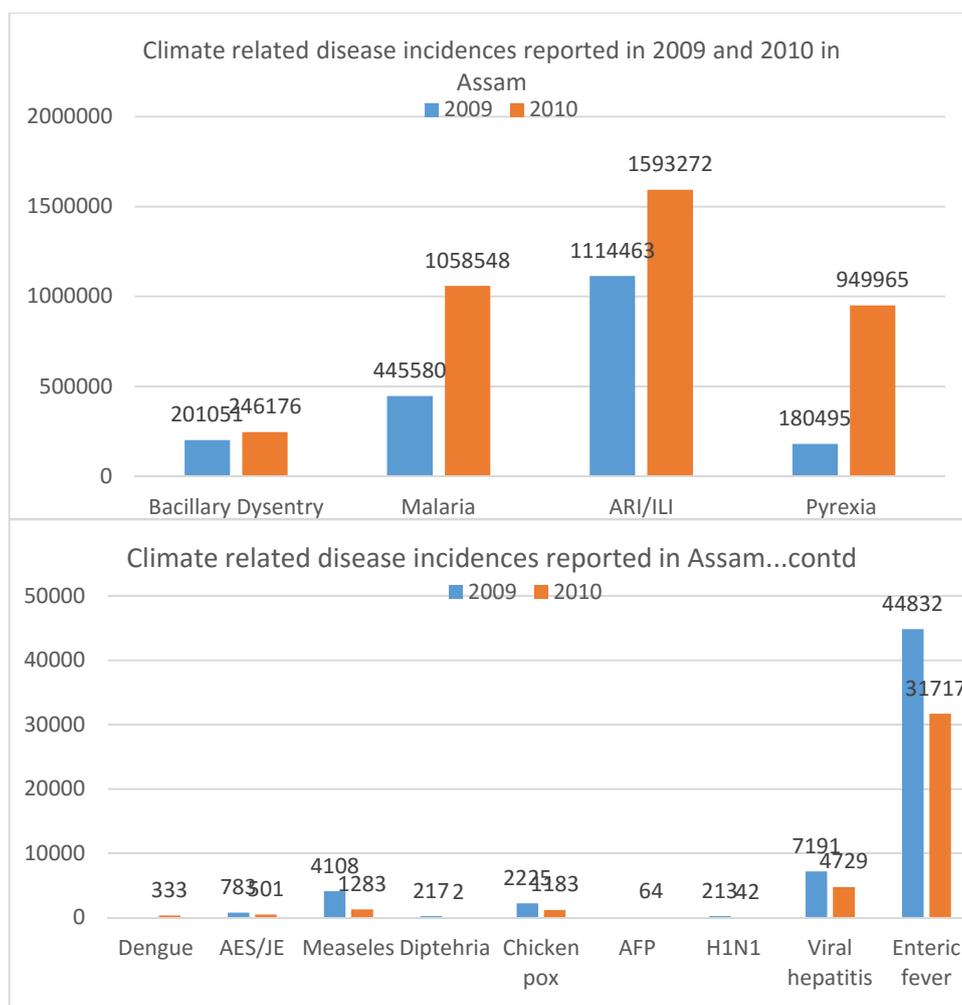


Figure 20: Climate related disease Incidences reported in Assam in 2009 and 2010⁶⁴

Disease prevalence in Assam continues to be high as it is one of the 18 states in India which have poor health service delivery systems. As a result, it is a focus State for the National Rural Health Mission (NRHM).

It is clear from figure 19 that ARI/ILI disease incidence are the highest followed by Malaria in the State. ARI is related to pollutant levels in the atmosphere which originate from various anthropogenic activities that use fossil fuel such as transport vehicles, industries, power plants etc. ARI incidences are likely to increase with continued increase in anthropogenic activities into the future and increase in ambient temperature.

On the other hand, malaria which is not dependent directly on fossil fuel burning but is a function of temperature, precipitation and humidity and vegetation cover continues to be one of the major Public Health problems in Assam. Out of total 31.53 million populations in the state, 9.71 million populations (31%) are living in malaria high risk areas. Malaria is particularly endemic in Karbi Anglong, Kokrajhar, N.C.Hills (Dima Hasao), Chirang, Goalpara, Baksa, Hailakandi and in Udalguri.

⁶⁴Integrated Disease Surveillance Programme of Gov of Assam, 2009-10, Available at:http://www.nrhmassam.in/state_pip/idsp.pdf

Further it is clear from figure 19, that morbidity related to heat waves – a consequence of an extreme climate event is not reported as a part of the Integrated Disease Surveillance Program (IDSP). Heat waves are already reported in the State and are likely to be more frequent and more intense in the future. Similarly, injuries and deaths due to floods, landslides are also missing in this list, which will escalate as climate change rolls out into the future.

If climate change continues as projected, the major changes in ill health compared to no climate change will occur and will be in the form of:

- More number of morbidity and mortality death due to more intense heat waves, cyclonic winds, landslides, mud slides, and flooding events and fires
- Increased risk of under nutrition resulting from diminished food production
- Increased risks of food and water-borne diseases (very high confidence) and vector-borne diseases
- Opening up of windows of transmission of disease-carrying vectors due to exceedance of thermal thresholds at higher altitudes
- More water and food borne disease incidences
- Effects of food and water shortages
- Air pollution-related health effects
- Psycho-social impacts on displaced populations
- Health impacts from conflicts over access to vital resources

Improving Basic Public Health and Health Care Services, creating policies that help towards prevention of certain diseases related to climate change, developing early warning systems through disease forecasting mechanisms etc. can be some of the adaptation strategies that can be brought in. Table 16 below gives some of the necessary strategies that can be implemented to adapt to climate change vis a vis emerging health issues in a climate change context.

Table 16: Strategies for protecting human health

Sl. no	Action	Costs (INR Cr)	Source of Fund	Priority	Department Responsible
1	Developing disease forecasting system for disease outbreaks on a daily basis in consonance with daily weather forecast	1.00	State/ Central Fund	VH	Deptt of Health and Family Welfare
2	Develop mobile based apps on disease outbreak forecast and prevention measures – a to do list	1.00	State/ Central Fund	VH	Deptt of Health and Family Welfare
3	Study and map new and emerging diseases in consonance with CC projections	1.00	State/ Central Fund	VH	Deptt of Health and Family Welfare
4	Extending IDS to urban areas and to private clinics	10.00	State/ Central Fund	VH	Deptt of Health and Family Welfare
5	Including heat wave incidences under IDSP in Assam	10.00	State/ Central Fund	VH	Deptt of Health and Family Welfare

					Family Welfare
6	Conduct studies to assess links between climate change and possible malnutrition in the State especially amongst children	1.00	State/ Central Fund	VH	Deptt of Health and Family Welfare
7	Review and retrofit disaster risk response strategies of the department in view of climate change using CSDRM tool	0.25	State/ Central Fund	VH	Deptt of Health and Family Welfare
7	TOTAL	24.00			

8.6 Managing Urban Space

In case of Assam, Urban spaces along the flood prone river bank are prone to excessive flooding during extreme rain fall events. Similarly, due to excessive rain fall, urban spaces near foot hills or on hilly terrain are at risk from landslides. Also the urban spaces are susceptible to enhanced heat island effect due to the continuous warming of the atmosphere. Both lead to disasters leading to morbidity of the population residing in these spaces and sometimes lead to mortality. Morbidity certainly impacts on productivity and their earnings.

In view of this, a few strategies suggested to protected urban spaces from consequences excess heat or rainfalls are indicated in the Table below.

Table 17: Strategies for making urban spaces climate resilient

Sl. no	Action	Costs (INR Cr)	Source of Fund	Priority	Department Responsible
1	Reevaluate drainage system of the urban space/city and realign it with the maximum expected volume water that will be received due to extreme rainfall and avenues and outlets required for dissipation. Pilot: 7 cities	3.50		VH	JNNURM
2	Map and Evaluate the landslide prone areas in a hill city and devise and implement adaptation strategies to bind the soil and prevent soil erosion and hence landslides- engineering as well as vegetative measures (take 3 hill cities)	15.00		VH	JNNURM
3.	To dissipate heat in open areas built up due to heat island effect design landscapes dotted with greens that can cool the micro climate (focus on 3 cities that have very high	15.00		VH	JNNURM

	temperatures in summers w.r.t. other cities in Assam)				
4	Strengthen disaster response of ULBs through Capacity Building (Cover: Guwahati, Silchar & Dibrugarh and 10 Towns viz. Tinsukia, Sivasagar, Jorhat, Tezpur, Bongaigaon, Nalbari, Nagaon, Mangaldoi , Dhubri & Kokrajhar)	6.5	ASDMA & Adaptation Fund budget		ASDMA
5	Training and capacity building of Community, NGOs, CBOs and Govt. Officials, educators, students on Disaster Risk Reduction and Climate Change Adaptation				JNNURM
	TOTAL	40.00			

9. Energy

9.1 Access to Electricity

The total power generation capacity in the State in 2014 has been reported as 0.51 Giga watt, of this 75% is thermal based, 19% hydro and 6% is renewable energy that includes biomass and solar⁶⁵. Bifurcation of thermal based power generation and renewable energy sources is shown in figure 21.

The energy requirement in 2013-14 was around 7434 MU, and supply available was 6965 MU⁶⁶. The peak demand was 1362 MW and in comparison supply was only 1218 MW- a shortage of 10.52%⁶². The transmission and distribution losses were of the order of 26.3% in 2013-14, as compared to loss of around 30% in 2011-12, indicating that T&D losses are reducing⁶².

Currently, while the city of Guwahati getting an average supply of 20 hours' other urban areas are getting an average supply of only up to 15 hours. Rural areas have much poorer power availability with an average duration of supply being just about 12 hours.

⁶⁵Energy Statistics, 2015. Ministry of Statistics and Programme implementation. Gove of India.

⁶⁶Statistical hand book- Assam, 2014

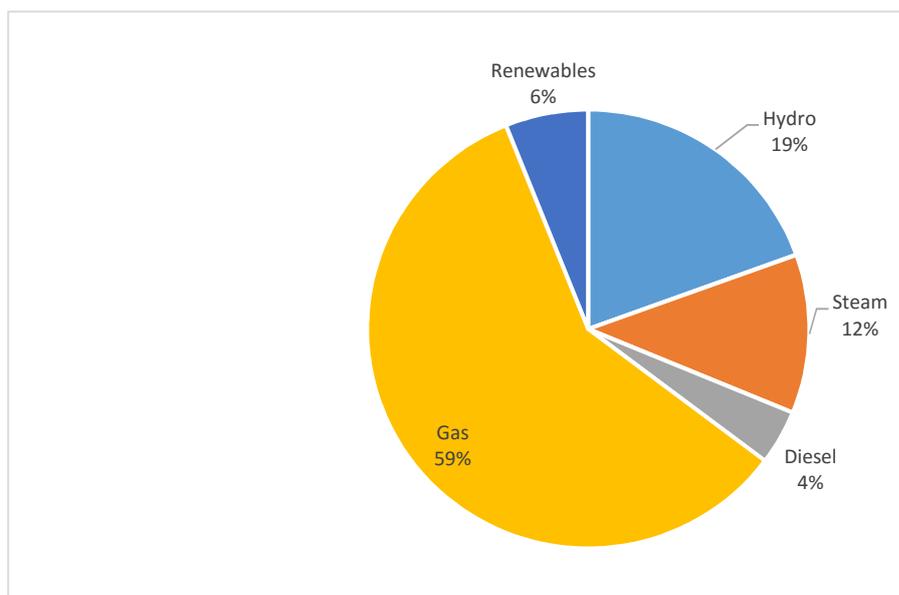


Figure 21: Power generation capacity by energy type

In addition to inadequacy of generation capacities, the power availability is also severely constrained by network constraints (both inter and intra state). The APDCL's serves electricity to over 32.38 lakhs consumers in the state. Electricity is only available to 37% of the total households in the State⁶², which is the third lowest next to Uttar Pradesh and Bihar, and significantly lower than the all-India average of 67%⁶⁷. Some of the power projects that are being implemented for capacity addition is shown in Table 20. In spite of these additions, Assam will have to generate more electricity to achieve its developmental goals,

Table 18: Ongoing projects for capacity addition

Project Name	Capacity (MW)	Brief Description
Namrup Replacement Power Project (NRPP)	100	Approximately 65% project work is complete. Open cycle commissioning is expected in December 2015

⁶⁷http://www.censusindia.gov.in/2011census/hlo/Data_sheet/India/Source_Lighting.pdf

Small Hydro Policy	<p>The Govt. of Assam has decided to encourage generation of power through SHP sources of energy and has framed a policy, which was notified in the gazette of March 2007. On publication of the policy, an investment avenue for approximately Rs 900.00 Cr has been opened up for Independent Power Producers (IPP)/User societies.</p> <p>The SHP Policy of the State Govt. included 90 nos. of potential small hydro generating stations ranging from 0.1 MW to 20 MW (total 148.50 MW), in different parts of the state. However, out of this 148.50 MW only 91.5 MW has the proven potential for small hydro power as per recent investigations carried out.</p>	
Myntriang Small Hydro Electric Project St.-I & 1.5 MW enhancement of St.-II	10.5	Approximately 55% project work is complete. Commissioning is expected in December 2015
Lungnit Small Hydro Electric Project	6	Contract with EPC contractor cancelled due to slow progress of work. New EPC contractor selection is pending due to high price bid cost than the estimated project cost.

Strategies for augmenting power generation capacities include 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. This is in line with the aspirations of the National Solar Mission that aims to implement 100,000 MW of solar power by 2022.

Table 18: Strategies for augmenting power demand in the State

Sl. No	Action	Costs INR in CR	Sources of fund	Priority	Implementing Agency
1	Setting up of 60 MW SPV Power Plant at Amguri, Assam	491.84		H	APDCL
2	Setting up of 2 MW SPV Power Plant at Namrup,	18.25		VH	APDCL
3	Setting up of 2 MW SPV Power Plant at Lakwa,	18.25		VH	APDCL
4	Capacity Building in APDCL	0.15		H	APDCL
5	Protection of Erosion of river bank for water intake pump at Desang river for Lakwa TPS	0.98		VH	APDCL
6	Master drain system of Lakwa TPS with ETP	0.24		VH	APDCL
7	Crude oil drain pit development for	0.04		VH	APDCL

Sl. No	Action	Costs INR in CR	Sources of fund	Priority	Implementing Agency
	gas intake station at Lakwa TPS & accumulator tank for Gas compressor lubrication drain				
8	Lower Kopili Hydroelectric Project (120 MW), Dima Hasao and Karbi Anglong Districts, Assam	0.28		VH	APDCL
9	Development of Small Hydro Electric Projects	0.60		H	APDCL
10	Switchyard illumination at Namrup TPS-LED	0.20		H	APDCL
11	Street lighting at Namrup TPS- LED	0.20		H	APDCL
12	Additional thermal Insulation on GT Unit #1, #2, #3 & #4 at Namrup TPS	0.14		H	APDCL
13	Anti-erosion measure at Dillighat Intake of Namrup TPS	1.0		VH	APDCL
14	Renovation / Repairing of cooling system of Steam Turbine unit-5, splash bar changing at Namrup TPS	1.00		VH	APDCL
15	Research and Development	0.75		H	APDCL
	Sub TOTAL- APDCL	533.92			
16	Development of State Renewable Energy Policy	0.25	Bilateral support		AEDA
17	Installation & Promotion of 25 MW aggregate capacity of Grid Connected Solar Power Plant at different vacant land of APDCL with capacity ranging from 1 MW to 5 MW	15.30	100%: GOA	VH	AEDA
18	Installation of Grid Interactive Rooftop/Ground mounted Solar Power Plant (with battery backup) at important Govt. Building of Assam with capacity ranging from 5 kW to 50 kW	73.89	90%: MNRE, GOI 10%: GOA	VH	AEDA
19	Illumination of important towns/historical locations of Assam through Solar Street Lighting System	22.50	100%: GOA	VH	AEDA
20	Installation of 1 MW aggregate capacity of Solar Wind Hybrid System with capacity ranging from 600 W to 10 kW	23.33	100%: GOA	M	AEDA
21	Installation & Promotion of 150 nos. of Solar Water Pumping systems for irrigation purpose	9.00	30%: MNRE, GOI 70%: GOA	H	AEDA
22	Electrification of 75 nos. of remote villages through Solar PV based power plant under DDG	52.50	90%: GOI 10%: GOA	VH	AEDA
23	Setting up 80 MW Grid Connected Solar Power Plant through IPP in BOO Mode	800.00	IPP	M	AEDA
	Sub Total- AEDA	996.70			

Sl. No	Action	Costs INR in CR	Sources of fund	Priority	Implementing Agency
	GRAND Total- Energy generation	1530.69			

9.2 Energy Efficiency

As per the Electricity Act 2001, Assam has requested the designated consumers, to appoint Energy Managers, carrying out of Energy Audit, publication of information relating to Energy Conservation and energy saving tips in local dailies, distribution of informative leaflets for the benefit of public, celebration of National Energy Conservation Day in association with ASEB etc. Cinema halls of Guwahati city were requested to display slides containing Energy Conservation messages during show intervals to propagate the message of energy conservation among public.

The Government of Assam issued Notification in July 2007 to use energy efficient lamps in Government buildings, Institutions, Board, Corporations and promotion of Energy Efficient Building Designs as per the Energy Conservation Building Code published by the BEE.

Further the National Mission on Enhanced Energy Efficiency (NMEEE) recommends decrease in specific energy consumption in large energy-consuming industries, with a system for companies to trade energy-savings certificates; provide Energy incentives, including reduced taxes on energy-efficient appliances; and generate financing for Public-Private Partnerships (PPP) to reduce energy consumption through demand-side management programs in the municipal, buildings and agricultural sectors.

Keeping this in view some energy efficiency measures have been suggested which can be taken up by the government.

Table 19: Some of the Strategies suggested for improving energy efficiency include:

Sl. No	Action	Cost (INR Cr)	Sources of fund	Priority	Implementing Agency
1	Explore fiscal mechanisms for supporting energy efficiency activities in the State	0.25		VH	AEDA
2	Ascertain energy efficiency potential in various sectors	0.50		VH	AEDA
3	Energy Conservation in buildings				AEDA
	Customize the ECBC code according to the various climate zones and seismic zones in Assam	0.50		VH	AEDA
	Enforcing BEEs energy conservation building code (ECBC) in all 14 major towns for -efficient lighting systems -Efficient cooling systems -Efficient heating systems	14.00		H	AEDA

Sl. No	Action	Cost (INR Cr)	Sources of fund	Priority	Implementing Agency
	Promote Energy efficiency in religious places through awareness generation	1.00		H	AEDA
	Design fiscal incentives for supporting private owners to follow energy efficiency regulation	0.25		H	AEDA
	Train managers on green building practices and auditing in all the 14 cities	14.00		VH	AEDA
4	Promote energy efficient Household appliances				
	Introduce scheme to replace 4 CFLs with 1 LED- awareness generation.	1.65		H	AEDA
	Tie up with LED producer, recycler.	0.25			
	Develop fiscal incentive for the by back process	0.25			
	Ensure presence of only 3 star and above domestic appliances (ACs, fridge) in markets	0.10		VH	AEDA
	Create a mechanism to extract heavy fine from any seller selling Air Conditioner and Refrigerator with energy efficiency that is rated less than 3 star	0.25		VH	AEDA
	Create awareness through media	1.65		VH	AEDA
5	Energy efficiency in Agriculture				
	Only star rated diesel/electricity driven pump sets to be sold in the market- awareness generation and enforcement	1.00		VH	AEDA
6.	Energy efficiency in Industries				
	Identify energy intensive SME clusters and identify energy efficient measures that can be propagated- A study	1.0		VH	AEDA
	Implement the measures through fiscal incentives	0.25			AEDA
7.	Promote energy efficiency in street lighting and external lighting in housing societies by introducing LEDs	0.25			AEDA
	TOTAL	37.15			

SECTION C: WAY FORWARD

10. Implementing SAPCC and Knowledge Management

10.1 Implementing SAPCC

It is proposed that a separate **Assam Climate Change Management Society (ACCMS)** - A Special Purpose Vehicle (SPV) will be created in the State, which will coordinate all SAPCC related activities and other activities related to climate change and will be an interface between line departments, State Government and domestic and international funding agencies that are providing technical and financial assistance to implement SAPCC and other Climate Change related activities. This agency will be staffed with technical experts and will have a governing body headed by the Honorable Chief Minister and a Steering committee headed by Chief Secretary. From each department of the State, there will be a nodal officer, Climate Change who will be dealing with all climate change matters in their respective departments and liaise with the subject matter technical experts hired in the Society. Climate Change Management Society vis-a-vis the implementation of the State Action Plan on Climate Change. The nodal department for coordinating ACCMS would be department of Environment and Forest, Government of Assam. Figure 22 schematically represents the implementation arrangement of all matters related to climate change in the state including implementation of the SAPCC.

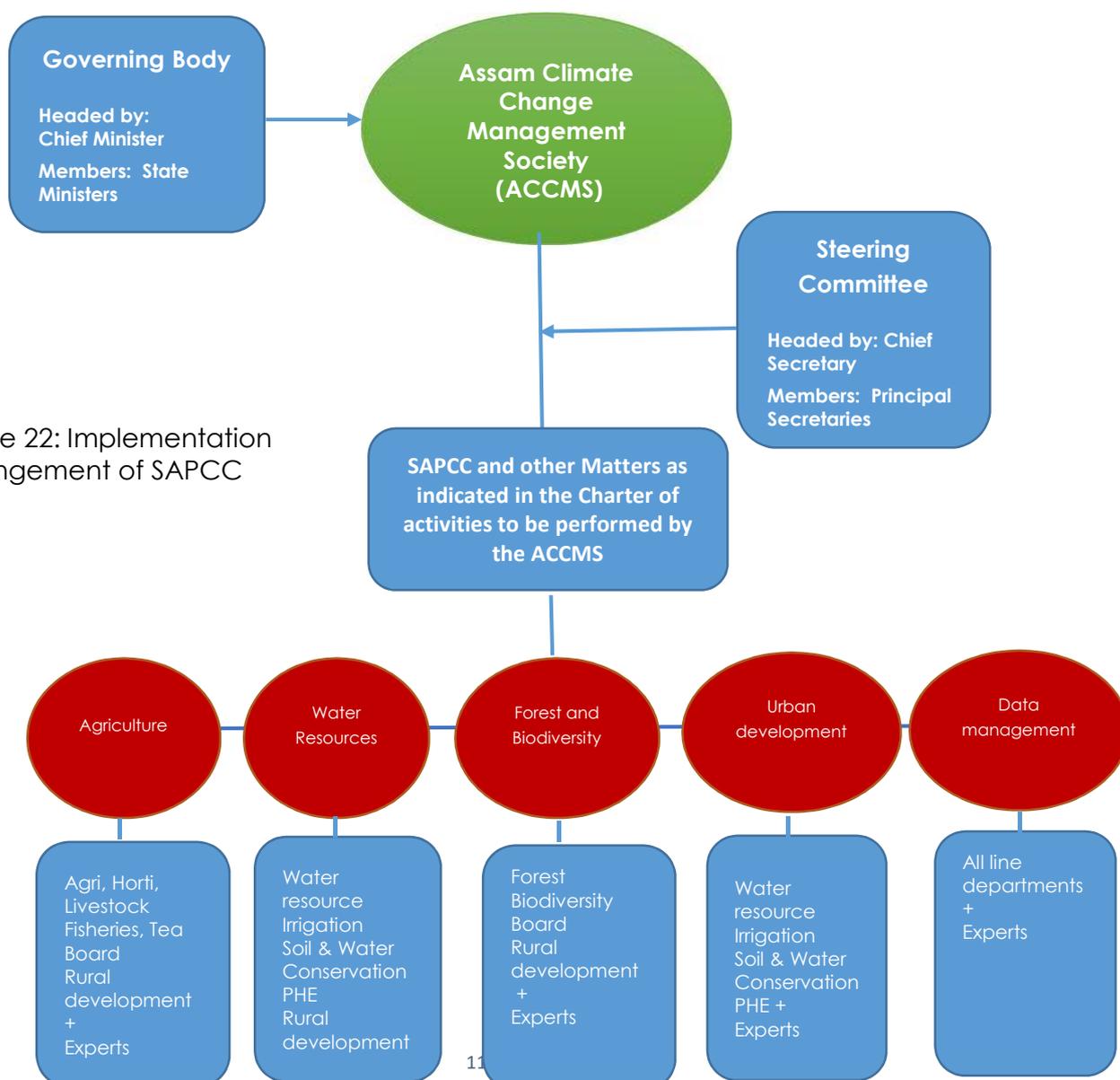


Figure 22: Implementation Arrangement of SAPCC

The roles and responsibilities of the various components of the Society are briefly mentioned below:

The Assam Climate Change Management Society: the roles and responsibilities the ACCMS will include:

- Implementation of the State Action Plan on Climate change and the projects and programmes emanating from it
- Update it on a regular basis as per the advancement of knowledge on climate change,
- Addressing the requirements of the National Action Plan on Climate Change from time to time
- Facilitate implementation of India's commitment if any to the UNFCCC
- Create Knowledge management platform and data base for informed decision for integrating climate change adaptation in planning in consultation with various agencies in the country
- Liaise with all departments through their climate change nodal officers
- Will formulate Monitoring and Evaluation framework to assess progress of projects and to assess that adaptation is taking place
- Will launch new studies that address mitigation and adaptation with funding from the State Governments/ central government/ various missions of the NAPCC/climate change funds – national and international
- Build capacity of natural resource and energy managers to address climate change within their domain
- Any other

The Governing body: the governing body will be headed by the Chief Minister and is responsible for policy planning and coordination, innovation, resource mobilization and for synergizing the efforts of the various stakeholders. The members of governing body will be the Ministers of various departments in the State and distinguished experts.

The Steering Committee: Will be headed by the Chief Secretary of the State and the members will be the head of departments. The role of the Steering Committee will be to provide guidance on all activities that will be undertaken by the Society.

Technical experts: The technical experts will be subject matter specialist with an overall knowledge of climate change science, impacts and mitigation. They will ensure implementation of all the envisaged activities mentioned as the role of the Society. The following specialists will be hired initially:

- Data Management, GIS and web portal hostile
- Water Resource
- Agriculture
- Forest and biodiversity
- Urban development
- Energy
- Any other

Cost implication for running the Assam Climate Change Management Society will be in the tune of 5.00 Cr in five years.

10.2 Knowledge Management

Knowledge about climate change, its impacts and associated extent of vulnerabilities, is a matter of strategic importance for all countries as they need to preserve and protect their natural resources, adapt to the changing climate and help contain the concentration of greenhouse gases in the atmosphere at a level that does not dangerously alter the climate system and jeopardize the security of human well-being vis-à-vis, its food security, economic security and environmental sustainability.

Formulation of integrated data bases is therefore of utmost importance, as this will enable researchers help policy makers to take informed decisions while formulating policies. It is proposed that knowledge management in the State can be done through support of various projects that explore the interaction of climate with various natural resources, the economy, society etc. and also through collation of knowledge/data products from other agencies which can throw light on these issues.

Producing the knowledge acquired for use of various stakeholders will also be an essential area of activity of the knowledge management component of the SAPCC.

Sl. No	Action	Costs (INR Cr)	Priority	Implementing Agency
1	Creating a knowledge Management portal- Assam Climate Change Knowledge portal and continuously update for next 5 years	1.50	VH	ASTECC
2	Build capacity within the State to analyse climate change trends and model projections	5.0	VH	ASTECC
3	Build Capacity to run impact assessment models for various sectors	3.0	VH	ASTECC
4	Assess district wise Climate Change vulnerability and hydro-meteorological hazard risk and develop adaptation plans for all sectors	1.0	VH	ASTECC
5	Scan all programs and policies of the government and advise the government as to how all can be made climate resilient.	1.0	VH	ASTECC
5	Develop advisory manuals on for all infrastructure design requirements to address exacerbated impacts of climate	1.0	H	ASTECC

	change in the State of Assam in its various regions			
6	Some specific studies			ASTECC
6.1	Study & Documentation of ground water level in the piedmont plain of northern Assam- Foot hills of Arunachal and Bhutan	0.048	VH	ASTECC
6.2	Assessment of alternate agri-practices in highly flood prone districts, 19 districts	0.38	H	ASTECC
6.3	Study of hill-slope destabilisation and urban flood management system (Guwahati City), 1	0.15	VH	ASTECC
6.4	Policy review in the context of climate change – Forest policy, agri-policy, draft water policy, industrial policy, 4	0.20	H	ASTECC
6.5	Identification of wetlands for due protection and management with proper study on hydrology, flora, fauna and economic value, 4 zones	0.60	VH	ASTECC
6.6	Identification and conservation strategies of Vulnerable biologically sensitive species, 4 institutions	0.40	M to H	ASTECC
6.7	Institutional capacity building to handle climate change programmes (all concerned govt. directorates) *, 10 programmes, each 2-3 days	0.50	VH	ASTECC
6.8	Development of core-group of climate change scientists in Assam (training for project development, core-support), 6 institutions	0.60	H	ASTECC
6.9	Hazard Risk Vulnerability including impact of climate change assessment including impact of climate change	2.00		ASTECC
7.	Capacity building of departments across all levels of governance towards integrating CC in Adaptation Plans	0.135	VH MH	ASTECC
8	Education & Awareness on climate change related issues through educational institutions	0.81	H	ASTECC
	TOTAL	18.32		

11. Integrating Climate Change finance in adaptation Planning

Recent modelling by the Asian Development Bank for South Asia suggested that economic growth would be between 2% and 6% lower by 2050 if climate change adaptation is not factored in development. However, funds required for undertaking adaptation measures need to be available to the governments. It is well known that the international funds are only a fraction of the fund required. Even in the case of Assam, the entire SAPCC budget estimate is indicating a fund requirement of INR 58026.17 Cr over next 5 years. i.e., each year about 11605.30 crores will be spent. This is only 7.3% of the State GSDP at current prices.

This amount can be availing pieces from various sources. If adaptation is not systematically undertaken, then this cost will go on increasing becoming a significant portion of the total GDP. Therefore, it is imperative that adaption cost be factored in each year within planning. Now the question is where will this money come from- either it can be through creation of some special fiscal instrument such as creating green cess for the State that will generate enough finance and support annual adaptation activities. However, if the budget is not enough considering the scale of adaptation required, then other mechanisms need to be developed. Therefore, the next step is to understand how every department can identify and factor in the adaptation budget requirements within their planning and develop fiscal instruments that can provide the financial support for undertaking such work on a regular basis.

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 Government of Assam for the SAPCC process, Mr. Saraswati Prasad, Principal 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. 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.

4. Meeting held on 25.02.2015

Venue: Room No -205, Assam Administrative Staff College, Guwahati

Date: 25th February, 2015

The meeting was presided over by Honorable Shri Atuwa Munda, Minister of Environment & Forests and Tea Garden, Government of Assam. Shri Davinder Kumar, Additional Chief Secretary, Department of Environment & Forests and Water Resources, Government of Assam, welcomed the Minister and the workshop

participants. The workshop was attended by 44 participants from various Departments of Government of Assam. He apprised all present in the workshop about the Assam SAPCC and its status. Shri Atuwa Munda mentioned that given the vulnerabilities and the multi-dimensional challenges posed by climate change, the government of Assam, is committed to address the same and the 1st step it has taken is to draft the State Action Plan and aims to implement it under the overall of India's National Action Plan on Climate Change. The government of Assam is focusing on climate resilient agriculture, Biodiversity conservation, Climate resilient urban planning, renewable energy - Solar, and improvement in rain-fed agriculture through extensive cultivation of pulses. He also thanks CCIP-DFID team for the technical assistance extended to govt. of Assam.

Mr. Abhay Kumar Johari, Addl PCCF, Government of Assam gave a brief presentation on climate change challenges of Assam that needs to be addressed and how the mandate of the Assam SAPCC can be aligned with the eight missions of the National Action Plan on Climate Change. He mentioned that the Department of Environment & Forests has sought financial projections for the strategies and actions articulated by various departments managing the various sectors impacted by climate change and a few departments are yet to submit the same.

All the departments were requested to reworked on the draft Assam State Action Plan on Climate Change with the help of CCIP experts and also finalize the financial projections against the strategies and actions proposed.

5. Meeting held on 22.07.2015

Venue – NEDFI House, Guwahati.

A one-day consultation was organized on July 22, 2015 by the Centre for Environment, Social and Policy Research (CESPR) and the Indian Network for Ethics and Climate Change (INECC) in collaboration with Assam State Disaster Management Authority (ASDMA), CCIP – CPGD, UK Department for International Development (DFID) at the Conference Hall of the NEDFI House, Ganeshguri where important sectors under SAPCC and climate change were discussed.

The consultation was designed to discuss and deliberate on important issues and areas in the state, including agriculture, water resources, energy, disaster, and forest and wildlife, and challenges which Assam is likely to face as a result of the adverse impacts of climate change.

The consultation engaged stakeholders comprising civil society, academicians, policy think tanks, government representatives, grass root level workers and representatives from media. The objective of the consultation was to seek reflections on SAPCC engagement from CSOs from other states of India in order to pick up relevant threads and build synergies. Expert input will be gathered from international policy watch groups to understand the link between state, national and international Climate and

development policy processes. The suggestions and recommendations from the workshop will be put forward to the Assam Government, for necessary action on the subject. The outcomes of the workshop were submitted to the nodal department for SAPCC, Government of Assam

6. Meeting held on 13.08.2015

Venue: Room No -205, Assam Administrative Staff College, Guwahati

The meeting was scheduled to validate and finalize the SAPCC of the State of Assam. The Inaugural session was presided over by the Honorable Chief Secretary, Govt. of Assam Mr. V.K. Pipersenia and Shri Davinder Kumar, Additional Chief Secretary, Environment & Forests and Water Resources Department presided the next sessions. The workshop was attended by over 45 participants. The purpose and objective of the meeting was to validate and obtain in principle approval of the State to take this document forward for its finalization.

Shri Davinder Kumar, Additional Chief Secretary, Department of Environment & Forests and Water Resources, Government of Assam, welcomed Honorable Chief Secretary, Shri V K Pipersenia and the workshop participants. In the inaugural speech, he apprised Chief Secretary and all present in the workshop about the Assam SAPCC process and its status. We are in the final stages of preparing the State Action Plan on Climate Change for Assam. The State Action Plan Climate Change is aligned with the missions of the National Action Plan on Climate Change (NAPCC) which are focusing on Adaptation and Mitigation as well from the Energy perspective Assam is also making its contribution towards increasing the share of Renewable in its total energy mix and special thrust is being given on solar.

Mr. Rizwan Uz Zaman, Team Leader, CCIP – DFID and Member Secretary, Climate Change Cell gave an overview of ASAPCC to the Chief Secretary and the participants of the workshops.

On conclusion of the presentation of the SAPCC, the Chief Secretary conveyed his in principle approval to the SAPCC and thanked the hard work of Environment and Forests department and CCIP – DFID team for completing the SAP document. However, he indicated that as the SAPCC is a dynamic document, it needs to be updated on a regular basis and therefore it's important to start implementing the strategies already identified in the present SAPCC, which each department considers a priority. The Chief Secretary further mentioned that one climate change nodal officer will be identified in each department and advised the departments to hire relevant subject specific Climate Change technical experts who can support them in taking forward the climate change actions being implemented by them.

Finally, Mr. Abhay Johri, addl. PCCF, took the session on the way forward for finalization of the SAPCC document. The Environment and Forest Department, Government of Assam will officially circulate the draft SAPCC report to all the departments. The state

departments are requested to provide their final comments on the activities listed in the document relevant to their departments and if no comments are received then the action plan for that particular sector will be considered as approved. However, an email notification from the relevant department that they approve the action plan for their related sector would be appreciated by the CCIP team.

Mr. Rizwan Uz Zaman, Team Leader, CCIP – DFID gave the Long Range Planning Exercise and gave vote of thanks to the all the members.

References

1. Ananthanarayanan, Sriram. 2008. Jhum cultivation under conflict in the Northeast. India Together. Published online June 27, 2008. Available from: <http://www.indiatogether.org/2008/jun/agr-jhum.htm>.
2. Approach to 11th Plan (Assam), 2010-Planning and Development department, Assam, Brahmaputra Board, 2007-2008.
3. Assam Science Society. 2002. State Biodiversity. Strategy and Action Plan Assam (Draft). National Biodiversity Strategy and Action Plan (NBSAP).
4. Assam State Government. 2007. Department of Agriculture Mandate. Available from http://assamgovt.nic.in/departments/agriculture_dept.asp.
5. Assam State Government. 2007. Department of Agriculture Mandate. Available from http://assamgovt.nic.in/departments/agriculture_dept.asp.
6. Assam Science Technology and Environment Council. 2011. Recommendations for State of Assam's Strategy and Action Plan on Climate Change. Available from http://www.indiaenvironmentportal.org.in/files/climate_change.pdf
7. Bonan, G.B. 2008. Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests. *Science* 320 (5882):1444 – 1449.
8. Chauhan, S. 2010. Biomass resources assessment for power generation: A case study from Haryana state, India. *Biomass and Bioenergy* 34:1300-1308.
9. Climate change and India A 4x4 Assessment, a sectoral and regional analysis for 2030s. 2010 INCAA: Indian Network for climate change assessment.
10. Das, P.J., Dadul Chutiya, and Nirupam Hazarika. 2009. Adjusting to Floods on the Brahmaputra Plains, Assam. Aranayak, Assam. Published by International Centre for integrated mountain development, Nepal Department of Environment and Forests (DEF), 2002. Draft Assam Forest Policy.
11. Documentation on past disasters, their impact, measures taken, vulnerable areas in Assam. 2005- Administrative staff college report.
12. Economic Survey of Assam 2003-2004. Available from: <http://www.assamgovt.org/ecosurvey/Irrigation.htm>.
13. Forest Survey of India. 2005. State of the Forest Report. Available from http://www.fsi.nic.in/sfr_2005.htm.
14. FSI, 2009. State of Forest Report, 2009. Forest Survey of India (FSI), Ministry of Environment and Forests, Government of India.

15. Brahmaputra Board: Chapter 20 - Report of Brahmaputra Board, Ministry of Water resources. Accessed online from: <http://mowr.gov.in/writereaddata/linkimages/anu1732289380.pdf>. Annual report Accessed on 15th February, 2011
16. India: Multi tranche financing facility - Assam integrated flood and river bank erosion risk management investment program. 2010. Facility Administration Manual, Asian Development Bank.
17. IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller (eds.)]. Chapter 11. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.
18. Kieberger, S, Johnson, A.F., Zeil, P., Hutton, C., Lang, S. Clark, M. 2009 - BRAHMATWINN International Symposium, Nov 9, 2009, Kathmandu, Nepal.
19. Kumar, B.B. 2006. Illegal Migration Bangladesh - Concept publishing company. India.
20. Mahanta. C, Pathak, N and Dutta, U. 2007. Water hazards in the Indo-Tibetan Brahmaputra basin: A regional climate change impact perspective - Geophysical Research Abstracts (Vol. 9).
21. 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.
22. Ministry of Development of North Eastern Region & North Eastern Council. 2008. North Eastern Region Vision 2020.
23. Northwest Hydraulics Consultants, Edmoton. Alberta, Canda.2006. Report on River Flooding and Erosion in Northeast India.
24. Paroda, R.S. and Sharma, S.D. 1986. Collection of rice germplasm in India: Current status and future plans. Report presented at the All India Coordinated Rice Improvement Project Workshop, NDUAT, Faizabad.
25. Planning and Development, Government of Assam. 2003- Assam Human Development Report.
26. Sarmah, R., M.C. Bora and D.J. Bhattacharjee. 2002. Energy profiles of rural domestic sector in six un-electrified villages of Jorhat district of Assam. Energy 27(1): 17-24. Available from "http://www.sciencedirect.com/science?ob=ArticleURL&_udi=B6V2S-4475SRT-2&_user=3214518&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000060044&_version=1&_urlVersion=0&_userid=3214518&md5=ab08bc907a5e41f5111fab71155610a0".

27. TERI 2010 - Integrated impacts and vulnerabilities assessment of communities' dependent on forest resources for livelihoods New Delhi: The Energy and Resources Institute. Second national communication to UNFCCC.
28. Transparency International India and Centre for Media studies.2008.TII-CMS India corruption study.
29. Water Resources Department, Government of Assam. 2010. Review of flood management measures and future vision in Assam. Presentation for third NEC Sectoral summit.
30. Attri, S.D. and Tyagi, A., 2010. "Climate Profile of India". Met. Monograph Environmental Meteorology No 1/2010, pp. 1-122.
31. Goswami, B.N., Venugopal, V., Sengupta, D., Madhusoodanan, M.S. and Xavier, P. K., 2006 "Increasing trend of Extreme Rain Events over India in a Warming Environment". Science, 314, 5804, 1442-1445.
32. Guhathakurta, P. and Rajeevan, M., 2008. "Trends in the rainfall pattern over India". Int. J. Climatol., 28, 1453-1469.
33. Dash, S.K., Kulkarni, M.A., Mohanty, U.C. and Prasad, K., 2009. "Changes in the characteristics of rain events in India". J. Geophys. Res., 114, D10109, doi: 10.1029/2008JD010572.
34. NATCOM, 2012. "India's Second National Communication to the UNFCCC". Ministry of Environment and Forests, Government of India, New Delhi.
35. Sathaye, J., Shukla, P.R. and Ravindranath, N.H., 2006. "Climate change, sustainable development and India: Global and national concerns". Current Science, 90, 3, 314-325.
36. <http://online.assam.gov.in/web/population-census>
37. Statistical Handbook- Assam, 2014.
38. <http://www.ibef.org/download/Assam-110313.pdf>
39. Directorate of Inland Water Transport of Assam.
40. <http://www.trai.gov.in/WriteReadData/WhatsNew/Documents/PR-TSD-120315.pdf>
41. Rathore L S, A D Attri and A K Jaswal, 2013. State Level Climate Change Trends in India. Meteorological Monograph No. ESSO/IMD/EMRC/02/2013. India Meteorological Department, Ministry of Earth Sciences, Gol
42. Jhajharia D, B K Yadav, S Maske, S Chattopadhyay, A K Kar, 2012. Identification of trends in rainfall, rainy days and 24 hr max rainfall over subtropical Assam in NE India. C R Geoscience 344 (2012) 1-13.

43. http://www.mdoner.gov.in/sites/default/files/silo2_content/Kfw/Project_Document_NECCAP-31052011.pdf.
44. Parry, M. L., Canziani, O. F., Palutikof, J. P., Van der Linden, P. J. and Hanson, C. E. (eds), Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, 2007, p. 976.
45. http://www.agriassam.in/etc/state_agriPolicy.htm
46. State of the Forest Report 2013, Forest Survey of India, Ministry of Environment and Forests, Government of India.
47. Homkala Devi and Pankaj Goswami, 2015. Analysis of Climate change on rainfall, temperature and discharge of Brahmaputra, IJIRAE, issue 4, vol 2, April 2015.
48. Statistical Handbook of Assam, 2014. Deptt of Planning, Gov of Assam.
49. http://www.agriassam.in/agriHorti_profile/Profile%20of%20Agri-Horti%20Sector%20of%20Assam-February%202013.pdf
50. Assam Economic Survey, 2014-15. Available at: http://planassam.info/contents_sub.php?username=&status=&q=25&link_name=25&ID=94&link_caption=Economic%20Survey%20&%20Statistics.
51. http://www.agriassam.in/etc/state_agriPolicy.htm
52. Jagadish S V K, K. Sumfleth, G. Howell, E. Redoña, R. Wassmann, and S. Heuer, 2007. Temperature effects on rice: significance and possible adaptation. Available at: http://climaadapt.org/wp-content/uploads/2011/12/Jagadish2007Rice_Impact.pdf
53. Agricultural Statistics at a glance, Government of India, 2012.
54. Datta S., 2013. Impact of climate change on Indian Horticulture, International Journal of Science, Environment ISSN 2278-3687 (O) and Technology, Vol. 2, No 4, pp 661– 671.
55. Tea Board of India.
56. <https://www.newscientist.com/article/dn27714-climate-change-causing-a-headache-for-assam-tea-growers-in-india>
57. <http://teaclimate.com/climate-change>
58. Hahn L G, 1999. Dynamic Response of Cattle to Thermal Heat Loads. Journal of Animal Science, Vol. 51, E. Suppl. 1, (January 1999), pp. 10-20, ISSN 0021-8112.
59. MoEF, 2011. India's Second National Communication to UNFCCC.

60. Kohli S, U. K. Atheya and A. Thapliyal, 2014. Assessment of optimum thermal humidity index for crossbred dairy cows in Dehradun district, Uttarakhand. *Veterinary World*, EISSN: 2231-0916 Available at: www.veterinaryworld.org/Vol.7/November-2014/3.pdf
61. <http://www.ndtv.com/india-news/six-die-in-assam-as-mercury-soars-to-highest-in-33-years-525231>
62. G K das and FA Khan, 2010. Summer Anoestrus in Buffalo- A review. *Reprod Dom Anim* 45, c494
63. Roy DT, A R Bhattacharya, and S N Luktuke, 1972. Estrus and ovarian activity of buffaloes in different months. *Ind Vet J* 49:54060.
64. Razdan, M.W., 1988, Buffalo performance in relation to climatic environment. *Proceedings of the II World Buffalo Congress*, 173-186.
65. Upadhyay R. C, S.V. Singh, A. Kumar, S.K. Gupta, Ashutosh, 2007. Impact of climate change on milk production of Murrah Buffalos. *Ital.J.Anim.Sci.* vol. 6, (Suppl. 2), 1329-1332.
66. Assam Science Society, 2002 climate resilient Animal shelters (community base) - with water harvesting.
67. Annual Report, 2013-14. Department of Animal Husbandry, Dairying & Fisheries; Ministry of Agriculture, Government of India.
68. Assam Economic Survey 2014-15. Directorate of Planning. GoA.
69. Sarma, Pradip Kumar, 2015. Fish Germplasm Diversity and their Conservation Status of River Kaldia in Lower Brahmaputra Valley of Assam, India. *Int. J. Pure App. Biosci.* 2 (6): 46-54. Available at: <http://www.ijpab.com/form/2014%20Volume%202,%20issue%206/IJPAB-2014-2-6-46-54.pdf>
70. Dutta, A. Choudhury, M. and Acharjee, B., 2007. Natural and anthropogenic hazards in cage and pen aquaculture systems in North-east India. In: *Natural and Anthropogenic Hazards on Fish and Fisheries*. Ed. Umesh C. Goswami, Narendra Publishing House, Delhi. 263-270pp.
71. Sharma, S. and Das, B., 2010. Global warming, climate change and its impact on fish diversity of Assam. In: *Proc. Int. Sem. on Climate change, Global warming and NE India: Regional perspectives*, ERD Foundation, Guwahati-29
72. Goswami, U.C., Basistha, S.K., Bora, D., Shyamkumar, K., Saikia, B. and Changsan, K., 2012. Fish diversity of North East India, inclusive of the Himalayan and Indo Burma biodiversity hotspots zones: A checklist on their taxonomic status, economic importance, geographical distribution, present status and

- prevailing threats. *International Journal of Biodiversity and Conservation*,4(15): 592- 613.
73. Vision 2050. Central Institute of Marine Fisheries, ICAR, Min of Agriculture, Gov of India.
74. FSI, 2013. Status of Forest Report, Forest Survey of India, Ministry of Environment and Forests, Government of India.
75. SRES 2010. IPCC Emission Scenarios, 2010. Published by the IPCC.
76. N. H. Ravindranath¹, *, Sandhya Rao, Nitasha Sharma, Malini Nair, Ranjith Gopalakrishnan, Ananya S. Rao, Sumedha Malaviya, Rakesh Tiwari, Anitha Sagadevan, , Madhushree Munsu, Niharika Krishna¹ and Govindasamy Bala; 2011. Climate Change Vulnerability Profile for the North East India. *Current Science*, Vol 101, no 3, pp384 to 394.
77. http://ecostatassam.nic.in/ads_assam%20at_glance.pdf
78. <http://www.nird.org.in/Rural%20Development%20Statistics%202011-12/data/section-1.pdf>
79. http://tccpassam.gov.in/urbanisation_last_decade.pdf
80. http://ecostatassam.nic.in/ads_assam%20at_glance.pdf
81. <http://www.nird.org.in/Rural%20Development%20Statistics%202011-12/data/section-1.pdf>
82. http://tccpassam.gov.in/urbanisation_last_decade.pdf
83. Census of India 2011
84. ADB 2011. Propose multi-tranche Financing Facility India: Assam Urban Infrastructure Investment Program. Report and Recommendation of the President to the Board of Directors. Project number 42265.
85. Cotton, W. R. and R. A. Pielke, 2006. *Human Impacts on Weather and Climate* (2nd edition). Cambridge, UK: Cambridge University Press.
86. Based on "Manual on Solid Waste Management" prepared by Central Public Health & Environment Engineering Organization (CPHEEO), Ministry of Urban Development, Govt. of India.
87. http://cpcbenvvis.nic.in/cpcb_newsletter/sewagepollution.pdf

Department of Environment and Forest,
Government of Assam, India