West Bengal State Action Plan on Climate Change

Government of West Bengal
Government of India

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Preface

Science has indicated that climate change is likely to have adverse impacts on most of the economic sectors in India that are driven by climate such as Water resources, Agriculture and allied services, Biodiversity and Forests. These in turn are likely to affect livelihoods dependent on these sectors. Human health is another area of concern as some of the diseases are propagated by vectors that are climate dependent.

To address these concerns, the Government of India first defined its policy vis a vis climate change in June 2008 through a National Action Plan on Climate Change. The eight missions covered in this action plan were considered with a view to design strategies for adaptation to climate change that would ensure and enhance ecological sustainability and explore solutions towards more efficient technologies. Keeping in view that the role of the states of India is key for translating national policies into action at sub regional level, and decentralizing NAPCC objectives into local context, it is important for the states to prepare their own Action Plans to address their specific Climate change concerns.

The Government of West Bengal understands that Climate Change can prove to be a threat as well as an opportunity for the state. Through a consensus, it has identified the key sectors and regions that are likely to be most vulnerable and require additional efforts over and above its existing programmes and policies. The sectors identified are Water resources, Agriculture, Biodiversity and Forests, Human Health, Habitats and Energy. Additionally, two regions have been identified as most vulnerable, namely, the Darjeeling Himalayan region in its northern boundary and the Sundarbans at its Coastal southern end.

The report identifies the key concerns due to climate change for each sector and presents strategies that are towards ameliorating these concerns and hence adapt to climate change. It also suggests steps towards energy efficiency and increasing the renewable energy mix. Further, actions have been defined within each strategy and are budgeted for the 12th and 13th plan, i.e for the next 5 and 10 years.

The 1st part of the SAPCC, published in 2011, included strategies for Water resources, Agriculture, Biodiversity and Forests, Human Health, Energy efficiency and Renewable Energy, and an outline for developing a Climate Change institute. In the present report, Chapters on Habitats, and on Sundarbans and the Darjeeling Hill region are also included.

The strategies have been developed by different working groups of the SAPCC, created one each for different sectors. The working group members include members from concerned line departments, researchers, academia, and NGOs. In certain cases, stake holders outside the working groups have also been consulted to understand the current concerns and the perception of climate change.

Executive Summary

The West Bengal Context

The geographical positioning of West Bengal is distinctive as it is the only state within the Indian region, which extends from the Himalayas in the North to the Bay of Bengal in the south, and has many perennial rivers flowing through the state. Therefore it enjoys an alpine as well as a sub tropical climate, has abundant water and fertile soils that support a wide variety of biodiversity in its forests, crops, livestock, and aquatic life and some of them are unique to the state. About 70% of the population residing in the rural areas draw its livelihood from the state's natural resource base, by pursuing agriculture, horticulture,, animal husbandry, fisheries, and by harvesting forest products. As the natural systems are all linked to climate, any change in climate is likely to disturb the efficiency of production of these systems, thereby impacting the associated economy.

In view of the trends of observations and projected changes in climate (see Box 1) and their likely impacts on natural and man made systems, GoWB, prepared a State Action Plan towards adaptation to climate change, which it perceives will be required to be adopted in addition to the ongoing programmes that address the concerns of development. The strategies in the action plan also provide an opportunity for the state to align its developmental objectives along a low Carbon path.

Box 1: Observed and projected changes in Climate in West Bengal

Observed trends

- Between 1969-2005 a net warming trend has been established in the annual average temperature
- Minimal decrease in maximum temperatures of the order of -0.25 to -0.5oC in the entire 37 year period
- Perceptible increase in minimum temperatures have been observed which ranges between +0.25 to +1.5^{o}C within the same period
- The total amount of monsoon rainfall, which accounts for more than 75% of total annual rainfall over the state, has not changed significantly between 1969-2005
- Tough high variability in inter-annual rainfall in time and space has been observed
- A clear positive trend in post monsoon (Oct-Nov-Dec) rainfall in almost all over the state has been observed during 1969-2005
- The intensity of extreme rain fall events has increased in West Bengal as concluded by the IMD
- In the coastal region, severe cyclonic storms are on the rise, though the total number of cyclones is annually declining.
- High rate of sea level rise at the rate of 5.7 mm/yr observed along West Bengal coast wrt to other stations along the entire Indian coast line.

Projected changes in 2021-2050 with respect to base line simulation for 1961-1990

- A likely increase in temperature between 1.8 to 2.4^{o}C.
- Total amount of precipitation during monsoon, is not likely to change with respect to base line scenario in most parts of West Bengal.
- The winter and summer seasons likely to experience lower rainfall with respect to base line.
- Sundarbans and Darjeeling Hill area are however projected to have more rainfall with respect to base line scenario.
- The intensity of cyclonic events is likely to increase further
- Sea surge heights might increase to 7.46 m with a hundred year return period
- Sea level will continue to rise in consonance with the global rise, however, the rise in absolute terms is likely to be higher along the West Bengal coast due to continuous subsidence

The design of the action plan is envisaged to facilitate the implementation of the various missions of the National Action plan on Climate Change (NAPCC) at a sub national state level. The NAPCC focuses on 8 missions, and they are, towards (i) harnessing solar energy, (ii) enhancing energy efficiency, (iii) sustainable agriculture, (iv) integrated water resources management, (v) sustainable urban habitats, (vi) sustaining Himalayan ecosystems, (vii) greening India through forests, and (viii) developing strategic knowledge.

This Executive summary highlights the process of preparation, the current concerns of each sector and that of the identified special regions, the climate change concerns and the suggested adaptation strategies.

Approach to the Preparation of the SAPCC

The work towards the development of the State Action Plan on Climate Change (SAPCC), has been done under the aegis of the Department of Environment, which is the focal point for climate change in the West Bengal Government. The preparation of the SAPCC started with a scoping workshop in March 2010, and thereafter a steering committee was formulated in the month of April of the same year.

The steering committee is headed by the chief secretary GoWB, with additional Chief Secretaries and Principal Secretaries of nine line departments as its members. Simultaneously a drafting committee was formulated as well, with members from these departments. Next a meeting of the drafting committee endorsed that the sectors - Water, Agriculture, Horticulture, Fisheries, Animal Husbandry, Human health, Forestry, Human habitats, and the regions of Sundarban's and Darjeeling Himalayas are the most vulnerable in West Bengal as identified in the scoping workshop. For moving towards a low C path, the committee recognised that role of enhancing Energy Efficiency in the energy and industry sector and increasing the share of new and renewable energy resources in the total energy mix of the state. The drafting committee also suggested that initiatives need to be made to develop an Institute for climate change that would support the government with scientific inputs for an informed decision making,

Thereafter 9 committee's/Working groups were formulated, headed by the the members of the drafting committe, to develop the background papers on each vulnerable sector and region. The Working group members included representatives of the line departments, academia, researchers, and NGOs. The implementation arrangements for undertaking the SAPCC work is shown in figure 1.

These working groups using published literature and through broad based consultations with line departments, researchers, academia, NGOs, and general public, drafted the sectoral chapters on Water resources, Agriculture, Forests and Biodiversity, Human Health, Energy efficiency and Renewable energy and Institute of for Climate Change and synthesised the

SAPCC, and submitted this 1^{st} part to the MoEF in April 2011. The 2^{nd} version, that is this version, now includes remaining chapters on Habitats, Sundarbans and Darjeeling Himalayas.

The Adaptation strategies for each sector and the two vulnerable regions were identified through the following steps:

- 1^{st} a review of each sector in West Bengal and the regions of Darjeeling Himalayas and Sundarbans was undertaken
- 2^{nd} - The current concerns of each sector and the regions were identified along with the Institutions and the government programmes, projects and activities that are supporting development and hence addressing these concerns
- 3^{rd} – An assessment of the current climate trends and the climate projection scenarios for the mid Century (2021-2050) were made
- 4^{th}- the likely climate change concerns and the corresponding adaptation and mitigation strategies that would ameliorate the climate change concerns were identified

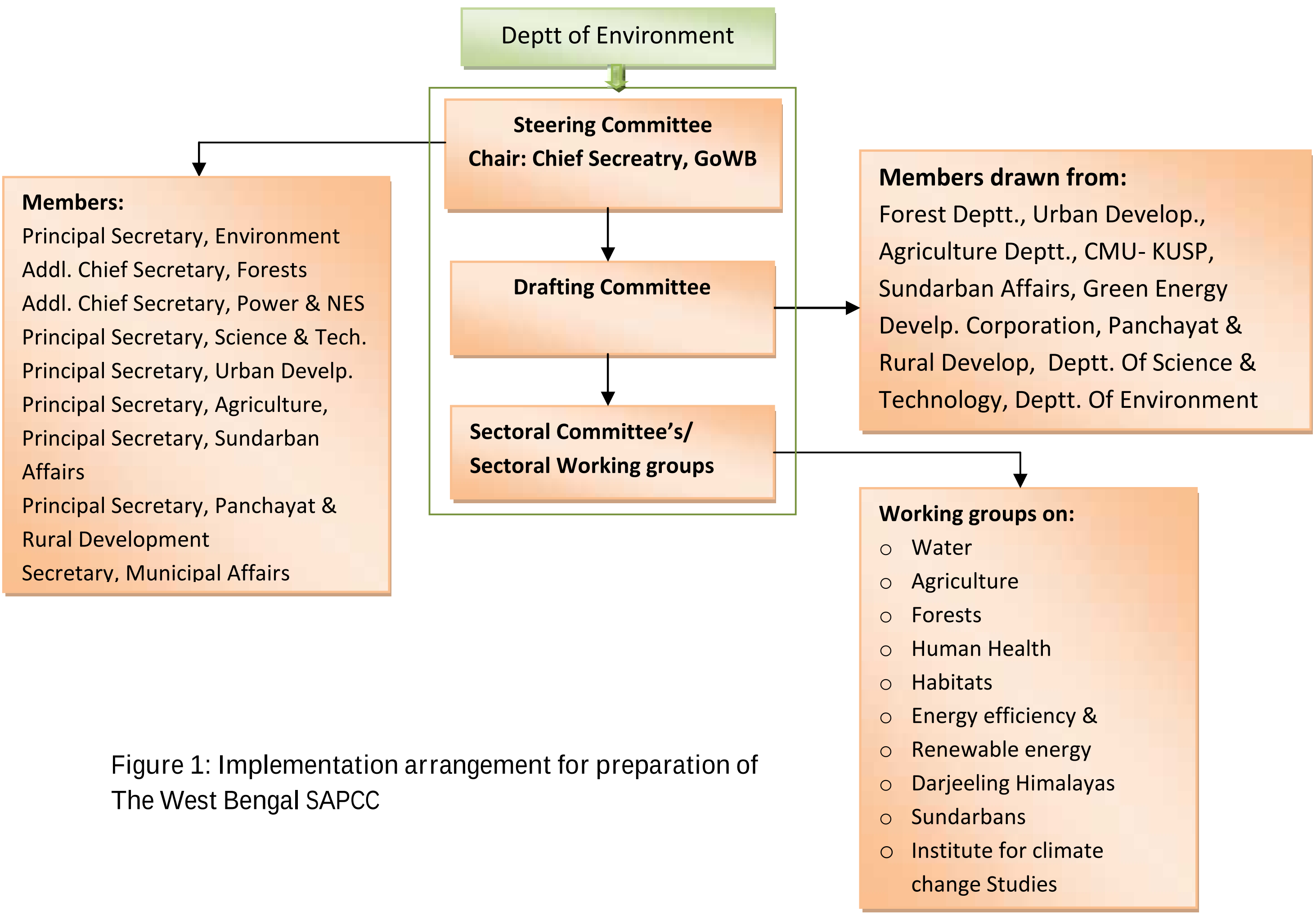

Figure 1: Implementation arrangement for preparation of The West Bengal SAPCC

Climate change Concerns and Adaptation Strategies

Water resources

Supplying water as per the current demands of each sector is a major concern for the state, With increase in population and development, the water demand for agriculture, industry, domestic use, drinking water, forest/ecology and energy is estimated to increase from 106.18 billion Cu m in 2001 to 452.82 Billion Cu m in 2051 (CPCB, 2009). Currently, the maximum demand is for irrigation in the agriculture sector but in the future the demand may be more from the energy sector. Further, ground water pollution, over exploitation of ground water in alluvial plains for agriculture, recurrent droughts and floods, cloud bursts, storm surges and cyclones in the coastal region accentuate the concerns associated with water resource augmentation and supply side management.

Climate change concerns: The key projections on the availability of rainfall in a mid century scenario (2021-2050s), does not suggest any major deficits in West Bengal with respect to the base line scenario, however, projections indicate a high regional variability in annual asell as seasonal rainfall across the state. The annual rainfall in Darjeeling Himalayan region and the coastal region is projected to increase in the mid century scenario. However, in the Himalayan region there is likely to be decreasing trend in winter rain fall. The increase in extreme rain fall events is likely to lead to higher run offs, and lower recharge of underground water, and frequent flash floods. Water availability is also analysed in terms of blue water flow (water yield - quantified rain fall plus deep aquifer recharge), green water flow (actual evapotranspiration), and green water storage (soil water). Future projections (2021-2050s) indicate a decrease in blue water flow with respect to the base line scenario (!961-1990), in almost all regions of West Bengal, except in the South 24 Parganas and in the Northern Himalayan region, an increase in the green water flow and almost no change in the greenwater storage, except a decrease in the Purulia and Medinipur regions. Further in the coastal region projections sea level rise and increase in intensity of cyclones are likely to exacerbate the concerns of potable water availibilty in these regions.

Adaptation Strategies: Since there are high spatial variation projecyed in water resource availability, a region based approach has been taken to devise strategies for water resource augmentation and management for West Bengal. The regions being the Hill region, the Alluvial plains, the Red and Laterite region and the Coastal region,

The Teesta entering West Bengal near Pedong·

Source: Photograph by Arnab Chatterjee, uploaded on Trek Earth,

Table 1: Adaptation strategies suggested for augmentation of the water resource and efficient management

Region	Suggested Strategies
Northern Hill Region	o Avoid water stress in the post monsoon and pre-monsoon period by storing excess run off during monsoon by increasing water storage capacities through rain water harvesting, ground water recharge, and reservoirs on rivers to transfer excess water to water deficit basins, check dams along rivulets, repair and renovate old rain water harvesting structures and encourage roof top rain water harvesting at household levels, communities and villages o Undertake scientific assessments to understand the impact of climate change on water flows in to the various reservoirs and adequacy of rain water and snpw melt receipts in future for hydropower generation
Alluvial Plains	o Increase surface water storage potential in view of increase in run off in the future due to increase in extreme precipitation events which will not allow sufficient ground water storage. Fuirther desilt existing dam reservoirs, water channels and old surface water storage structures. o Regulate ground water extraction, by phasing out rampant dispersed extraction and develop area specific ground water recharge centres that can be used for extraction and distribution of water through pipes or channels.. o Abate floods, by making arrangements for channelling of flood water, by improving drainage systems and introducing new drainage systems in areas that do not have them. o Assess return periods of floods and develop advance warning systems
Red and Laterite	o Undertake special afforestation programmes to enhance the recharge capacity of springs in and around the spring sheds where dexrease in

zone	spring flow is being observed. Further enhance stream flow by facilitating stream recharge along the slopes of the hills. ○ Create check dams intercepting rivulets, nalas, and create trenches out of the check dams to irrigate fields. ○ Enhance surface water storage in existing reservoirs (ponds/dighi's) and create new surface storage structures wherever possible. ○ Support the implementation of the planned Subarnarekha barrage at the earliest for augmenting irrigation in the area
Saline Coastal Zone	○ Increase surface water harvesting structures to increase irrigation coverage ○ Encourage rain water harvesting for potable water ○ Built mechanisms to avoid mixing of potable water with saline water during floodsby storing potable water over ground in tanks at built on stilts. ○ Bridge the gaps in the embankment
Scientific Assessments	○ Assess water demand by sector by including climate change scenarios ○ Monitor quality of water to assess pollution loading due to warming ○ Develop systems for effective dissemination of early warnings of cyclones amongst the population ○ Develop flood warning systems for alluvial plains
Policies as strategies	○ Extend metering of water and charge water use in all urban centres to encourage efficient use. ○ Undertake community based census of minor irrigation structures to detect dis-functionalities and initiate remedial measures much before the 5 year cycle of minor irrigation census. ○ Encourage water efficient irrigation systems such as drip irrigation, water sprinklers for agriculture ○ Extend compulsory roof top water harvesting to all urban centres in WB

Agriculture

The agriculture sector in West Bengal is characterized by the predominance of small and marginal farmers with per capita land holding being less than 1 ha. Rice is the dominant produce in the alluvial and coastal zone, and horticulture crops dominate productions in the hill and the terai region. Though there is a limitation in land availability for agriculture, but high levels of ground water extraction in the alluvial plains have enabled West Bengal to be number 1 in the country vis a vis rice production. Such levels of over extractions of ground water may be unsustainable in the future.

Further, a decrease in yields of crops grown in the Rabi season is being observed. Also increase in infestation of pests and diseases is being reported in rice and horticultural crops. Further the soil health is deteriorating in the state, necessitating external nutritional augmentation.

The livestock population in West Bengal is large, but milk productivity is low, and does not meet the nutritional requirement of the population, mostly because of lack of adequate feed availability for the livestock.

Climate Change Concerns: With increase in winter temperatures, decrease in yields of Rabi crops is anticipated such as wheat, horticultural crops such as potato and that of oil seeds including mustard. Further, as the annual average temperatures is projected to exceed by more than 1^{o}C in the future a reduction in rice yields with respect to current levels is expected. Availability of quality seeds might be a concern in the future. In the coastal areas, increase in sever cyclones together with the continuous sea level rise is likely to inundate areas further inland rendering the soils excessively saline and making agriculture unviable in the region.

Excess summer temperatures leading to heat stress, shortage in feed, increase in pests and diseases and higher levels of humidity are are likely to reduce milk production in livestock, including egg production in poultry as livestock suffer heat stress.

Horticulture products being sensitive to temperature rise, may see decline in productions, but shifting of cultivation centres at higher altitudes may be profitable.

In marine and freshwater systems, rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation may lead to shifts in ranges and changes in algal, plankton and therefore lead to deacrease in fish abundance. or change the location of availability.

Adaptation Strategies: The adaptation strategies have been suggested in keeping with the typical climate change concerns of the various regions, as agriculture is a function of soil, water and climate. The following tables represent the key adaptation strategies from the list of strategies provided for each sub sector.

Table 2a: Adaptation strategies to address climate change concerns for the Agriculture crops

○ Plan agro-climatic zone wise production of crops to maximise productivity to harness the typical combination of climate, soil, water and the biodiversity. Also develop and

disseminate amongst farmers region wise packages of technologies for water conservation, soil conservation, soil nutrient augmentation, and organic pest management for each crop type.
o Fortify soil nutrition by following a sequential cropping system suitable for different agrocliamtic zones in the state
o Popularise indigenous rice varieties and introduce new cultivars of rice, and other important staple crops including maize that are thermal resistant, can endure water stress, tolerant to salinity, and are fortified with nutrients for growing in soils deficit in corresponding nutrients. Cultivars ofcourse need to be selected that are suitabke for each agroclimatic zone. Maize is a C4 plant, which can also bear higher concentrations of CO_2, as compared to other C3 crops.
o Popularise Integrated Farming systems to combine crops, livestock, and fisheries for a self sustained farming system
o Store germplasm of indigenous cultivars from different agroclimatic zones, and strengthen research and development for water resource conservation technologies, developing new climate proofed cultivars, nutrient management, organic pest management, Identification of crops for crop diversification, Identification of traditional hardy, nutrient rich crops appropriate for each zone
o Devise Insurance packages against crop failure especially to small and marginal farmers to avoid migration keeping in view the specific reasons of crop failure in the different regions.
o Provide assistance to marginal farmers for enhancing the marketability of crop produced by them – such as thrashers, crushers, accessibility to markets, minimums support price etc.

Table 2b: Adaptation strategies to address climate change concerns for Horticulture

o Encourage horticulture production as per the typical biodiversity of each agro-climatic zone in keeping with the aims of the horticulture missions
o Develop packages that include measures on water resource conservation, soil conservation and Integrated Pest management as per the requirement of each agro-climatic zone
o To avoid heat stress due to projected increase in temperatures, immediate adaptation can be in terms of providing shades to vegetable crops and in the long run, heat resistant cultivars can replace the use of shades.
o Improve marketability of horticulture products by facilitating post harvest storage, transport and access to markets.

Table 2c: Adaptation strategies to address climate change concerns for Livestock

o Encourage breeding of small ruminants amongst marginal farmers such as black Bengal goat, garole sheep and Ghungru pigs for ensuring livelihood security of small and marginal farmers and hence enhance their adaptive capacity. These species are more hardy and are likely to survive the projected increase in temperatures.
o Encourage enhanced feed and fodder development through integrated farming systems, nixed cropping systems, use waste lands for growing feed, and through agro-forestry. A central fodder bank might also be thought of to store fodder for using during drought.
o Upscale veterinary services to manage new and emerging pests and diseases for all livestock and ensure accessibility of these services in all regions
o Ensure availability of cattle sheds and water bodies/sprinklers in all areas to avoid consequences of heat stress
o Undertake research to develop livestock that is a mix of indigenous and cross bred to

	develop hardy cattle and ensure adequate milk production
o	Undertake capacity building of farmers to ensure climate proofing of livestock and live stock products vis a vis type of livestock to be reared, shelters to be provide, type of feed to be provided, and for managing diseases and pests in a changing climate scenario.

Table 2d: Adaptation strategies to address climate change concerns for Fisheries

o	Undertake real time monitoring of fish shoals to assess quantum of fish arrival at various point sof rivers and in different times of the year
o	Disseminate real time climate information to inland fish growers, to help them cast appropriate fish seeds in appropriate climate conditions to realise maximum produce.
o	Develop climate forecasting and simulation modelling for better management of fisheries in the state
o	Protect and extend mangrove cover to enhance nutrient content in brackish water and enhance fish production and safeguard livelihoods of fishermen in the coastal areas
o	For enhancing the adaptive capacity of the fishery industry, assess the impacts of climate change on both inland and marine fish harvested in West Bengal. This will enable mapping of fish schools as water temperatures change, and help identify new species that may enter the waters in this region (inkland and marine) from other regions due to climate change.

Biodiversity and Forests

Though the forest cover is increasing every year, for example between 1988 and 2009 the forest cover has increased from 14.32% of the total state area (WBSFR 2009-10) to 14.64% ISFR, 2011), but the quality of forest is continuously decreasing. Even the latest State of the Forest Report (ISFR 2011), shows a decrease in dense forests and moderately dense forests by 3km^2 and 2km^2 respectively with respect to what was reported in ISFR 2009. The open forest area by 2km^2 within the same period. The other concerns of the sector are over extraction of timber and NTFPs, encroachment into forest areas, man-animal conflict and forest fires.

Climate change concerns and opportunities: With increase in precipitation, a shift in vegetation type towards the wetter, more evergreen type is expected. Since these are rather slow growing, the replacement will take much longer, and increased mortality in the existing vegetation may lead to a decrease in the standing stock except in the Western part of the state near Purulia and Birbhum where the vegetation type may become xeric. The net primary productivity of the forests is also likely to increase.

Even if there is no drastic shift in the biome type, changes in the composition of the assemblages are very likely. Further, as temperatures increase, spring and summer events will advance in time leading to early leafing, fruiting, bird egg laying, spawning of amphibians, arrival of migrant birds and insect emergence etc. As survival of the vegetation is also linked with the changes in timings of functions of the biota with temperature, a few species may show steep decline in population and perhaps may move to higher altitudes or become extinct.

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Forests in Darjeeling[1]

Mangrove forests in Sundarban[3]

This in turn very likely will impact other taxa dependent on the different species (i.e domino effect) because of the interdependent nature of the plant-animal-microbe communities that are known to exist in the forests ecosystems. This could lead to major changes in the forest biodiversity. The nature, extent and type of infestation of pests and diseases is very likely to change ans temperature and humidity rise. The other impacts could be on the NTF produce, any decrease in the NTFPs would impact the livelihoods of the population dependent on forest products

The positive aspects of climate change, will be in terms of enhanced sequestration of CO_2, as slow growing broad leaved vegetation, have high sequestration potential. The sequestration levels will increase with increase in forest area under this vegetation type.

Adaptation Strategies: Suggested adaptation strategies for forest and biodiversity are summarised in Table 3. They are mainly alighned along the objectives of the Green India mission.

Table 3: Adaptation strategies for forests and biodiversity

o Enhance the quality of moderately dense forests and open forests to increase the dense forest cover in the state and also to increase the C sequestration potential.
o Undertake afforestation activities in feasible areas outside forests to further increase the Carbon sequestration potential of the state with appropriate species suitable to the climate
o Estimate base line C sequestration potential of the West Bengal forests, and track the changes in C stored, because of the various actions taken by the government/people for conserving these forests.
o Undertake afforestation activities to improve spring flows in hilly regions i.e in the Himalayan and the Red and Laterite region within West Bengal

[1] Face book source, Forest Deptt of West Bengal

○ Facilitate species migration – both flora and fauna for them to adapt to climate change
○ Protect degraded forest areas from land slides due to increase in extreme events
○ Ensure that communities that help conserve forests get paid for the ecosystem services they help provide

Human Health

Continuous increase in incidences of vector borne diseases such as malaria is being observed in the state though preventive measures are being taken. Example, malaria has increased by 55% between 2008 and 2010. The most endemic zone of malaria is Kolkata where more than 60% of the incidences in the state are reported. The other less endemic areas of the state being- Purulia, Jalpaiguri, Murshidabad, and West Midnapore.

Water borne diseases such as Cholera, Diarrhoea and Enteric fever continue to be high in West Bengal and 20 to 27 lakh cases are reported each year. Enteric fever cases are becoming virulent in Darjeeling area as attack rates have doubled between 2008 and 2010. In the case of Cholera, though the disease incidence is decreasing but Kolkata, North24 Parganas and South 24 Parganas seems to be a constant reservoir of the disease.

The other region specific health issues that are linked to climate are the morbidity and mortality rates due to - cyclones in the coastal areas, respiratory diseases arising from inhalation of pollutants from heavy vehicular traffic in urban areas and from burning of fossil/fuel wood for cooking in rural areas. Incidences of sunstrokes from intense heat are also quiet high in West Bengal, though number of cases between 2009 and 2010 show a decline.

As per the data available on rural health infrastructure in West Bengal from the Ministry of Health and Family Welfare website (http://mohfw.nic.in/NRHM/State%20Files/wb.htm, accessed on 1st April, 2012), shortfall in health infrastructure is a matter of concern in the state. Still 20% of the desired number of sub centres, primary health centres and community health centres need to be established. About 6051 number of multipurpose female workers exists, which is only 60% of the requirement. The biggest, shortfall is in terms of specialists, only 13.3% of the workforce exists. Pharmacists and laboratory technicians are also woefully small in numbers

Climate Change Concerns: Increase in diseases burden amongst children, women and old is likely to increase as this group is the most sensitive. Vector borne diseases are likely to move to higher altitudes (Bhattacharya et al., 2006) where they are not existing now, for example, vectors may become active in upper reaches of Darjeeling and Cooch Bihar. As relative humidity and temperatures increase, in areas like Kolkata, increase in vegetation growth is likely to provide more conducive habitats for malaria. Thereby malaria is likely to emerge as the most menacing disease agent for this mega city. Similarly, water borne diseases might increase with increase in flood frequency in plains and intensity of cyclones in South 24 Parganas as potable water availability gets affected. Since the pollutant load bearing capacity of the atmpsphere increases with increase in temperature, the respiratory diseases incidences are also likely to increase in the state unless source control is carried out. Malnutrition levels amongst the children may also increase , with less availaibility of food grains due to decrease in yields of staple crops with increase in temperature, unless replaced with C4 crop grains that are more CO_2 and heat tolerant. Further, higher maximum temperatures as compared to current average temperatures would lead to heat stress and therefore morbidity.

Strategies for adaptation: In the health sector, the strategies would essentially include bridging gaps in the present infrastructure. Further an assessment of climate change on various climate related diseases, their spread, identification of new diseases that might emerge, location of emergence and associated projected morbidity and mortality rates in the future would enable the government to climate proof its health policy. The adaptation strategies suggested for this sector is presented in Table 4.

Table 4: Adaptation strategies for the Health sector in West Bengal

o Initiate research to study the impacts of climate change on all vector diseases, respiratory diseases, water borne diseases, and extent of malnutrition to quantify morbidity and mortality rates in future population, to identify vulnerable regions and population in the state, and for integrating climate change concerns in the health policy of the
o Bridge existing infrastructure gaps in the health sector and identify additional needs in line with the climate change impact modelling results
o Strengthen and develop an integrated approach for management of vector borne diseases, in different agro meteorological zones, water borne diseases (coastal and inland), Heat stress (all areas of WB), Respiratory diseases (All areas of WB) and for controlling of Malnutrition amongst schildren keeping in view the climate change projections for the drivers of diseases and the projections of the impacts on the disease that takes care of source correction, identification of diseases, deployment of treatment, monitoring
o Develop a nutrition policy for the state keeping in view the changing availability of various food grains as the climate changes
o Develop early warning climate related disease forecast capacities to enable the masses and the govt to take pre-emptive action
o Integrate climate change in health disaster risk reduction plans for Cyclones, floods and droughts
o Advisory from the health department may be provided to strictly implelemt policy of replacing existing chullahs with efficient chullahs to avoid pollution from burning of fossil fuel and fuel wood used for cooking in rural areas and for shifting to green mass transport systems, that will include a mix of alternate fuel based vehicles, smart traffic systems for efficient energy consumption in vehicles, non motorised transport in congested markets in urban areas and implementing policies for having less number of

	cars per day on roads, and for reducing risk of respiratory diseases amongst a large population, .
o	Initiate telemedicine facilities in rural and remote areas for deploying super speciality advise, include plans for rapid transportation of critical patients from remote areas.
o	Communise rural health care to enable communities to assess their requirements, access funds and facilities as per requirements and audit progress.

Energy efficiency and Renewable energy

Considering that accessibility to electricity drives growth, penetration of electricity in the rural areas is low in West Bengal, as is exemplified by the fact that only 40.3% of the rural households are electrified (Census 2011). Also requirement and supply statistics of electricity scenario for the entire state shows that in 2009-10, the electricity requirement was of the order of 33750 MU, but actual availability was 2.8% less at 32819 MU (CEA, 2010[2]).

Coal is the predominant energy for generation of electricity in the state. The annual electricity generation targets are impeded by shortfall in coal– as against the requirement of 50,000 tons of coal only about 42,000 tons are available of which 15% is imported. Sharply deteriorating coal quality over the years has increased coal consumption for the same amount of power generation. High ash content in the coal creates operational problems. Also power plants located away from the coal pits, have problems of availing imported coal because of logistical problems and steep hike in tariff (Source: Power generation scenario; www.wbpdcl.co.in).

As per the CEA base line CO2 emission estimates, in 2010, the total amount of CO_2 emitted from fossil fuel based power plants of West Bengal was around 51.9 million tons[3]. For meeting majority of the projected future demand, generation of additional power in the state centres mostly around use of coal as it is the most abundant in the state. Also, West Bengal has a huge scope for accessing and using coal bed methane, and has started operations in Raniganj and Sohagpur blocks in West Bengal for extracting the same.

As far as increasing the renewable energy mix is concerned, West Bengal is already producing hydropower in Darjeeling district as well as in Purulia. The state is well placed in terms of availability of other renewable energy sources such as solar radiation, biomass, and wind energy. The total annual energy generation potential from renewable is about 17,950 MW (Draft Renewable Energy Policy - West Bengal (PWC, 2010) and WBREDA (2010)). In the future, tidal energy also can be explored considering its proximity to the sea.

Climate change concerns: A low C path, can be achieved in the energy sector in a number of ways, by moving towards high efficiency of generation of power from thermal plants, by

[2] Source http://www.cea.nic.in/archives/plg/power_glance/nov10.pdf

[3] CO_2 base line data for power plants in India, Data base ver 7.0, Published by CEA

increasing the share of renewable in the total energy mix, and by changing the end use behavioural pattern.

Climate change can impede these ambitions. The direct affects may be loss in T&D due to impact of higher temperatures, increasing frequency of extreme rains and severe cyclones on transmission and distribution lines in the state. Further, warming is likely to increase the water requirement of the thermal power plants, especially used for cooling, which might not be available sufficiently. Melting of glaciers, from where 6 rivers in North Bengal originate, and which are used for Hydropower generation may get affected. Additionally, availability of biomass, a renewable energy source might be affected.

Table 5: Adaptation and mitigation strategies for energy sector

o Increase the share of renewable in the grid power by atleast 20% by 2020, by introducing (a) Solar photovoltaic in areas where waste land is available (e.g. Purulia, Bankura) where wasteland or abandoned mine areas are available, (b) by replacing use of grid power for certain end-uses through low temperature solar thermal – e.g. water heating, (c) increase hydropower capacity, (d) increase wind power capacity, and by (e) increase biomass for power generation
o Reduce anticipated energy and peak demand in the BAU scenario by managing demand-side Energy efficiency measures in identified consumer categories through -Efficient-device penetration facilitated by financial, supply chain and market incentives, Adequate financial incentives for lowering specific consumption, and State-led adoption for enabling critical volumes of devices and technologies in local market and breaking current cost barriers
o Improve supply-side energy efficiency by enabling lower system losses (technical and commercial), and enabling improved efficiencies in energy production
o Introduce new technologies for thermal power generation to enhance energy efficiency and hence lower GHG emissions
o Undertake research to assess the impacts of climate change on power infrastructure and devise remedial measures

Habitats

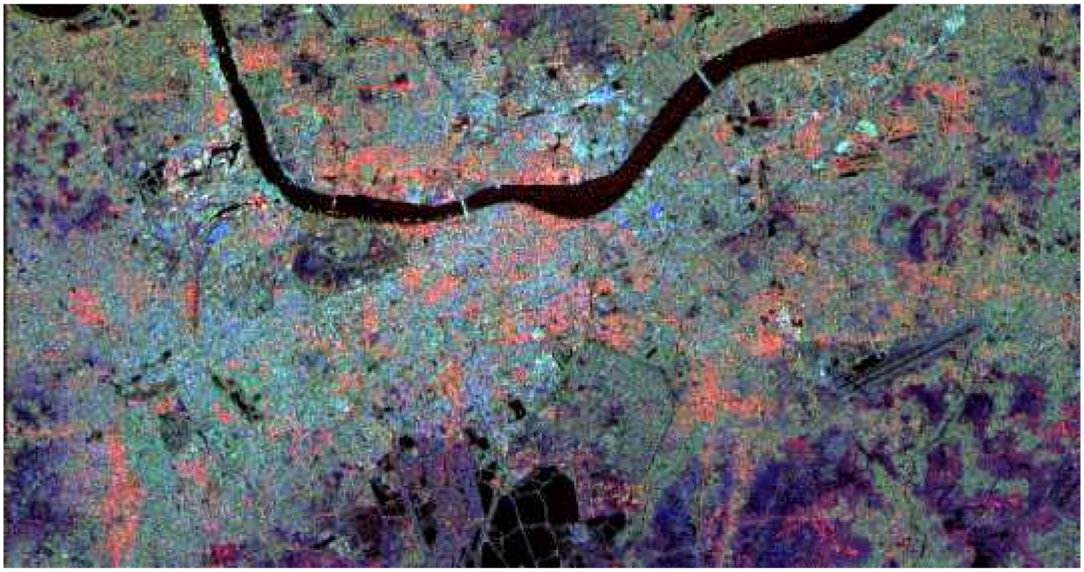
Current concern: West Bengal is the fourth most populous state in India, with a population density of 1029 persons/skm, which is nearly three times the national population density.

A significant part of the state is relatively backward economically, and also tends to be less advanced in terms of human development (WB HDR, 2004). These include large parts of Darjeeling, Jalpaiguri, Cooch Behar, Malda, Uttar Dinajpur and Dakshin Dinajpur, Purulia, Bankura, Birbhum and the Sunderbans.

Of the 25.8 million urban population, 84% reside in 27 Class – I cities with a population of more than 100,000. The urbanisation rate at 28% is higher than the national average. Further, the trend of growth of non-agricultural land, decrease in net sown area, increasing population densities, increasing share of industrial workers and traders, growth in road net works point to rural areas (and significantly the peri-urban areas) of the state acquiring urban character.

A paper by Khan et al, 2012[4], categorises West Bengal having high level of housing shortage. 64% of the rural households live in kuttacha and semi pucca house and 91% live in pucca houses in urban areas (NSSO, 2010).

87% per cent of rural households and 88% of urban households have access to safe drinking water (Census, 2001), which is better than the national average. However, nearly, one in every



Urbanisation in Kolkata
Source: Space radar Image of Kolkata. Source: NASA/JPL[5].

two households (46%) in urban West Bengal has to collect water from outside premises, while about one in every five rural households have to travel more than 200 meters to access drinking water. The SWID investigation reports that groundwater in 81 blocks is contaminated with arsenic and 49 blocks by excess fluoride. There is a high variation in status of urban water supply, with per capita availability, ranging from as low as 10 litres per capita per day (lpcd) to as high as 225 lpcd. On an average, 2only 0.9% households are connected through household connections.

As per the NSSO, 2010 report, 36% rural households and 10% in urban areas do not have access to toilets. Of the 3,354 Gram Panchayats, nearly a third (1,041) are Open-Defecation Free by November 2010, while 37 Panchayat Samitis have also achieved this status. There are significant differences in sanitation attainments across districts, with Darjeeling, Purulia, Uttar Dinajpur and Malda showing slow progress.

The state generates about 27 Million TPD of solid waste with a collection efficiency of 70 per cent (CPCB, 2008). Segregation is reported in only 6 ULBs. Only 10% of the waste collected in

[4] Jabir Hasan Khan, Shamsad, Md. Mustaquim; 2012. A comparative analysis of housing shortage and levels of deprivation. European Journal of Social Sciences, ISSN 1450-2267 Vol.27 No.2 (2012), pp. 193-205
[5] Accessed from: http://archive.org/details/VE-IMG-502

urban areas is reported to be treated and disposed in a scientific manner, leading to an emission of 0.147 million tons of CH_4 annually[6]. Generally, Districts with good economic growth exhibit comparatively better services, example, districts in KMA – Kolkata, Howrah, Hoogly, North 24 Parganas and South 24Parganas. Medium service levels are observed in medium-growth districts – Bardhwan, Birbhum, Darjeeling, Nadia and Murshidabad. The Municipal solid waste water treatment capacities are also very low, for example the city of Kolkata generated 706 MLD of waste water but capacity for treatment is only 172 MLD.

The NSSO survey 2010, notes the non-existence of proper drainage network in almost all ULBs. Drainage pumping capacity was reportedly inadequate, with inadequate capacity of most drainage outfalls. Severe water-logging in congested city areas and low-lying areas during the monsoons was a reported regular feature.

The urban sector contributes about 60% of the secondary and tertiary State Domestic Product (SDP). The urban areas are also the centres of institutional and cultural activities and provide health and educational facilities to the region. The spatial planning and development of the urban areas are therefore very important to ensure the growth of the activities in the urban areas and thereby providing the required boost to the economy of the hinterland as well as to the State. While the spread of urbanization has positive impacts and created opportunities, it has also created many problems that act as barriers to improved quality of life. The cities are faced with problems of inequality, increased competition for basic needs and competition in access to essential services, and health threats.

The vehicle population has witnessed a CAGR of 9% over the 1997-2006 period. The transport sector is also a major user of petroleum in the state, making it a source of GHG emissions. As the vehicle population is increasing, so is the emission of GHGs from this sector. Within 2005-06 to 2010-11, the CO_2 emissions from the transport sector have increased from 5.4 million tons to about 8.0 million tons[7], at a CAGR of 10.4%. Heavy density of transportation are mainly centred around the cities that line the highways and main railway networks and heavy freight movement in the state is due to its status as a gateway to the north eastern states. Inter state railways helps 1 million people commute to and fro to Kolkata every day for work. The intermediate transport from railway station to work is provided by auto rickshaws and hand driven rickshaws, providing livelihood to a large portion of the population.

The other state specific concern are the frequent climate related hazards of cyclones, heavy precipitation events which pose serious threat to infrastructure. Also extreme heat will have implications on future energy demand.

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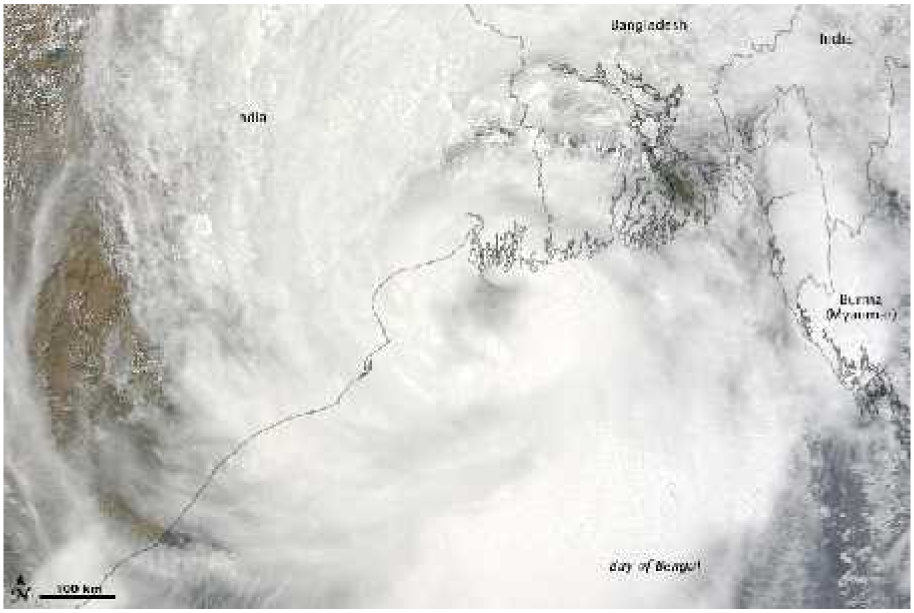
[6] Estimates made using IPCC methodology and EFs specified in INCCA report 1, 2010.

[7] Estimated using IPCC 1996 guidelines. Data supplied by the WB govt on fuel use in transport sector. Energy conversion factors used from IPCC 1996 guidelines, and EFs used as per INCCA Report 1, 2010

Concerns due to climate change: The direct impact of climate change on habitats is likely to be in terms of impacts due changes in spatial variation in hydrological cycle and the type of rain fall received. Higher intensity of extreme rain fall would mean flash floods and land slides leading to heavy economic losses through damage of infrastructure, houses, human lives, and domestic assets. Increase in intensity of cyclones would mean , higher levels of sea level rise, and stronger storm surges would have implications on the coastal infrastructure. Increase in temperature, would mean, not only the heat stress for the population, but increase in energy demand in cities, as the heat island effect magnifies.



Cyclone Aila from the space

Increasingly the cities are getting more populated as work opportunities are higher here. As a result of the influx, the urban sprawl is likely to expand further. Unless it is planned, non-regulated peri-urban settlements will dot the outskirst of the cities with no provisions of proper housing, sanitation, drainage, access to potable water, health services etc. Vulnerability of the peri urban population will escalate. Therefore, the state government will have to provide access to basic services such as adequate housing, drinking water, sanitation, public health services to adapt to the impacts of floods, cyclones, excess heat. Further increase in population will mean increase in solid waste generation, increase in vehicular transport and increase in electricity consumption in domestic and commercial sectors. All these have implication on enhanced GHG emissions, and mitigating the same will be a challenge.

Adaptation Strategies: The Habitat sector, essentially will need to focus on adaptation vis a vis the projections of climate change as well infuse higher level of energy use efficiency and GHG mitigation technologies for household and commercial appliances, transport sector, municipal solid waste, waste water being a part of requirement of habitation will also need to have strategies for containing GHG emissions as the number of vehicles on roads grow.

Table 5: Adaptation strategies for the habitat sector

- Set targets for efficiency enhancement and GHG emission reduction with respect to the BAU scenario through following actions but not limited to-
  - Transport Sector through comprehensive planning, fuel economy standards, introduction of solar and electric rickshaws and auto-rickshaws; and nonmotorised transport in congested areas
  - Methane capture in managed Solid Waste systems and domestic Wastewater streams
  - Reduce electricity intensity to reduce emissions indirectly - Municipal Management (Water Pumping and Public Lighting being electricity-use segments);
  - Reduce electricity intensity to reduce emissions indirectly – Commercial energy consumptions (Public and large Private Buildings being electricity-hungry)
- Increase system and citizen capabilities to adapt to temperature and rainfall changes anticipated Increased Warming, Changing Rainfall Intensity and temporal pattern and Extreme Events
- Undertake risk mitigation of anticipated impacts from Climate change through
  - Improved risk assessment of lifeline infrastructure for likely scenarios of climate change
  - Investment and implementation of infrastructure-strengthening initiatives and Warning systems to cope with extreme events
  - devise climate based insurance mechanisms

Special Regions

Two special regions have been identified by the state, as the most vulnerable regions vis a vis climate change because of the significance of their location, and they are the Darjeeling Himalays and the Sundarbans.

Darjeeling Himalayan region falls within the Darjeeling district in the northern border of the state. The Hill region is governed by the Gorkha Hill Council, and the Terai region is under the governance of the Darjeeling District Administration. The Hill region is important for the state, as the 6 perennial rivers entering from this region in addition to the Ganges entering from the western border, makes West Bengal one of the most water rich states in India. The region has 38% of area under forests, which is 17.61% of the total forest cover of West Bengal with vey high species richness of biodiversity. The forests produce superior quality timber and NFTPS. Darjeeling Tea is the most globally well known commercial produce of the region, though other horticulture products such as orchids, medicinal plants, mandarin oranges, and vegetables have a significant production potential in the area. Tourism brings in the much needed economic impetus. This is also a region within the state, where hydropower is harnessed for meeting a significant portion of the electricity demand of the population.

The region is blessed with high levels of rainfall (2718 mm), but high run off lead to soil erosion and frequent landslides render extensive damage to infrastructure, agriculture and to the human population in general. Also high runoff, does not allow enough water to be stored to ride over the lean period, when rainfall is scanty making the area a water stressed region. The Tea industry is dogged by old plantations, low level of productivity, and high costs of production. The forests though rich are more and more turning into open forests with dense and moderately dense forest cover reducing, thus affecting the biodiversity and hence the forest produce. Further, the Darjeeling city and Siliguri city in the Tearia region are seeing tremensous rise in population which are creatin pressures on existing infrastructure such as housing, roads, access to drinking water and sanitation.

A view of Darjeeling town from the Tea gardens. Source: Wikepedia

Development in the hill region has been slow. Low developmental paradigms if they continue, coupled with climate change are likely to have adverse effects on the physical and man made systems in the region.

Climate change concerns in this district include

- Concerns of water availability in the lean periods
- Heavier soil erosions and land slides with increasing rainfall intensity
- Shifting of agriculture production centres to higher altitudes,
- Lower produce of Darjeeling tea as the climate creating its special aroma changes
- Impact on horticulture produce such as the Darjeeling Mandarin
- Increase in pests and diseases, and emergence of new ones
- Impact on hydropower production due to melting of glaciers
- Impact on forests and its biodiversity, NTFPs including medicinal plants, and typical orchids
- Impacts on human health as vectors move to higher altitudes and people are subjected to heat stress , which they have never encountered
- Adverse impacts on human habitats as frequency of extreme rainfall increases and temperatures rise

The adaptation measures suggested are summarised in Table 6.

Table 6: Adaptation strategies for Darjeeling Himalayan region

Water	○ Assess water demand by sector for the Darjeelig district in view of climate change and increase in population in the mid century

	○ Develop a water policy for the district for augmentation of the resource as per the requirement and for efficient management ○ Create additional reservoirs to store excess runoff water in the monsoon and water from additional rainfall projected to be received during Oct-Dec period ○ Prepare for combating adverse impacts of projected rise in extreme precipitation events – land slides, soil erosion ○ Prepare monitoring and evaluation plans to check the integration of climate change concerns in water management
Agriculture	○ Facilitate agriculture cropping centres to survive at lower latitudes even at higher temperatures ○ Promote Indigenous food crops of the region so as to maintain food security in a climate change scenario ○ Undertake soil conservation and anti slide measures along hilly slopes growing crops and along roads to avert soil erosion and loss in soil nutrient ○ Promote integrated management of emerging and current pests and diseases ○ Intensify agricultural activities in the Rabi season
Biodiversity and Forests	○ Plan activities to reduce open forest area, enhance quality of moderately dense forests and protect dense forests from degrading ○ Empower communities living in and around forests to manage forests for enhancing its quality, for conserving biodiversity, preventing fire and benefitting through payment for ecosystem services rendered ○ Establish long term systematic monitoring of flora and fauna in Darjeeling Himalayas ○ Devise suitable strategies for conservation and facilitating species migration to adapt to climate change
Darjeeling tea	○ Avoid shifting of production centre to higher altitudes through development of cultivars that are thermal resistant and also retain the special aroma ○ Combat adverse impacts of droughts through soil and water conservation measures and creation of drought resistant cultivars ○ Combat excessive soil erosion and land slide due to likely increase in extreme rain through land cover technologies ○ Manage Pests and Diseases via organic route
Horticulture Medicinal plants, Mandarin Orange, Orchids	○ Enhance quality of dense forests to retain soil moisture and ambient forest moisture that are conducive to the growth of medicinal palnts and orchidsas well ○ Also develop heat resistant crop cultivars ○ Facilitate drainage of water during excessive rain ○ Avoid soil erosion ○ Develop cultivars that are thermal resistant to enable flowering and fruiting in sync with seasonal changes ○ Develop and implement packages for Integrated management of pests and diseases ○ Disseminate technology through KVKs ○ Prevent fragmentation of forests as they destroy the moss on which the

	orchids thrive
Ecotourism	○ Develop eco-tourism policy for the district with a focus on biodiversity conservation (see details in the Chapter 12)
Urban habitats and Transport	○ Undertake a detailed assessment of water requirements and availability in the future as temperatures rise ○ Develop a blue print for addressing the additional energy requirement of the district in the context of climate change through the renewable energy route ○ Assess the Retrofitting requirements and design for large Hydropower reservoirs keeping in view the climate change impacts ○ Map and treat the erosion prone areas in and around urban habitats keeping in view the projected extreme rainfall intensity scenario ○ Identify and make provisions for supply additional energy needed for space cooling ○ Develop Integrated Transport plan for all the towns of Darjeeling district with focus on meeting future transport demand GHG mitigation

The Sundarbans, on the other hand lie in the Coastal region of the state. The mangrove forests of the Sundarbans have been protecting the state from cyclones since time immemorial. The mangrove forests of the region house very sensitive and rich flora and fauna, the most famous being the Sundari mangrove trees and the Royal Bengal Tiger. The brackish waters of Sundarbans are home to rich catch of fish, crustaceans, and mollucs as they are filled with the nutrients generated by the roots of the mangroves and biomass deposition. The Sundarbans region has a low human development index, especially because of the exceptionally high population density, low per capita land holding, low access to potable water, sanitation, education and health. Further, majority of the population lives off agriculture, which is not productive due to salinity of the soil, and as there is no industry in the region. Sea level rise and recurrent cyclones exacerbate the salinity of the soil and also damage human wealth on a regular basis.

Studies suggest, that in the last two decades, the run off in the eastern rivers of Sundarbans has decreased leading to higher and higher salinity and greater sea water-sulfate concentrations. Furthe decrease in fresh water run off, would affect mangrove production. Continuous submergence in higher water depth due to sea level rise, would lower rates of photosynthesis and growth, the plants will become shorter and narrower, have fewer branches and leaves, and more acid-sulfide in their soils. Also sea level rise affecting availability of sediment would have effect on establishment of new groves. Increased mangrove growth rates predicted due to increasing atmospheric CO_2 may be offset by decreased growth resulting from changes in tidal regimes.

Faunal species that are tolerant of increasing temperatures (e.g., fish, gastropods, mangrove crabs and other crustaceans) may adjust rapidly to the changes. In contrast, soft-bodied animals and bivalve mollusks would be very sensitive to higher temperatures. Desiccation that would accompany increasing temperatures would harm many marine species associated with mangroves[8]. For mangrove-dependent species, however, the most serious consequences of a changing climate would likely be the loss of habitat as the mangrove forests declined.

Increase in incidences of morbidity and mortality might be registered due to increase in water borne diseases as water is likely to become un-potable as saline water spreads inland with increase in sea level rise and increasing intensity of cyclones. Water logged conditions also might increase incidences of dengue and lead to increase in malaria vectors and incidences. Similarly increase in intensity of cyclones is likely to cause more injuries and deaths. Higher temperatures may lower yields which already are not enough for the burgeoning population of the region. Also with more and more area getting inundated by cyclones and higher storm surges, salinity in the soil will increase affecting agriculture further (the recent example being the imoacts during cyclone Aila).

Typical Fauna of SUndarbans

Table 7: Adaptation strategies for Sundarbans

Develop protection against projected increase in cyclone,intensities, sorm surges and higher sea level
○ Undertake a study to generate low , medium and high scenarios of impacts of climate change on cyclones,storm surges, and sea level rise along the Sundarbans coast, for 2030s, 2050s, and 2080s to enable informed decision making and implementation of measures towards adaptation. ○ Identify the level of tolerance of the various existing mangrove species to the different levels of projected salinity and flood water depth. ○ Identify, the type and density of the mangroves required to act successfully as the 1st level of defense and accordingly, undertake afforestation through mangrove plantation. ○ Construct/retrofit the embankment along the sea as well as along the rivers based on

[8] Kjerfve, B. and Macintosh, D.J. (1997). Climage change impacts on mangrove ecosystems. In " Mangrove Ecosystem Studies in Latin America and Africa" (B. Kjerfve, L.D. Lacerda and S. Diop, eds), pp. 1-7. UNESCO, Paris

the likely return periods and maximum heights of storm surges that can occur o Based on the studies, scientifically raise the existing houses in vulnerable areas on stilts based on the level of flood water height likely to ingress in the future. Also Identify safe areas, and build/strengthen cyclone shelters for people as well as livestock. o Mobilise communities to take action rapidly and cyclone proof themselves when early warnings are sounded by authorities vis a vis moving people and livestock and their valuables to safer places o Strengthen communication – roads and telephony
Protect agriculture productivity and livelihoods o Height and quality of the embank plays a great role in protecting agriculture in the region from additional salinity in soil due to projections of increasing intensity of cyclones o Introduce thermal resistant and salt tolerant rice cultivars which can sustain under deep water conditions for long period o Promote commercial level coconut plantations in saline areas o Promote production of vegetable crops suitable to the region o Provide market linkages
Promote fisheries as an industry o Conserve mangroves to extract fish and other crustaceans from the mangroves and brackish waters o Promote inland and marine fisheries o Devise methods for real time mapping of fish catch in marine waters and inland to guide the fishermen towards these areas o Formulate a fishery policy for the Sundarbans (inland and marine fisheries) centering around conservation vis a vis climate change impacts
Enhance accessibility to Drinking water o Exploit the fresh water availability in the western rivers o Rain water harvesting and storing in community overhead tanks o Exploitation of ground water
Enhance accessibility to Health infrastructure o Bridge the existing health infrastructure and health service delivery gaps o Communise health service delivery o Develop tele-medicine facilities o Develop rapid transportation to hospitals for critically injured – by pressing in helicopter services o Develop disaster preparedness to abate disease outbreaks and undertake regular drills
Conserve biodiversity o Carry on with the existing biodiversity conservation activities of the Deptt of Forests and Biodiversity Boards

Cross cutting Issues

Implementing adaptation strategies and mitigation action would mean doing it through a systematic manner, which would entail

- Devising strategies (policies/programmes/projects/actions) based on informed decision making i.e based on sound scientific assessments
- Setting up a monitoring and evaluation framework for averting mal adaptation
- Building Institutional Capacity to integrate climate change concerns in planning
- Seeking appropriate financial resources

Towards Informed decision making: For informed decision making the West Bengal Government intends to set up an Institute for Climate Change. The proposed institution will undertake scientific research in collaboration with other established institutions and develop communication to translate climate change information for useful applications by different stake holders. It will also undertake training to disseminate climate change information for use in research, for field level implementers of CC actions and to policy makers. The indicative research areas are but not limited to:

- Atmospheric observations and modelling including climate change modelling,
- Research on land use, land cover and soil and their interface with climate science
- Impacts of climate change on biodiversity and forests and their role in supporting life forms
- Impact of climate change on hydrology and its sustainable management in the future
- Interaction of climate and health and devising future policies
- Understanding impacts of climate change on agriculture and developing adaptation models
- Energy studies for enhancing energy efficiency, and exploring use of renewables, study new renewable energy sources such as tidal energy and its applicability in the West Bengal context, explore pathways for developing a low C society, explore mechanisms for earning C credits, do supply and demand side management in various climate change scenarios etc.
- Socio-economic analysis in conjunction with climate scenarios to ascertain the requirement of scale of adaptation and adaptation funds.
- Developing policy, programme, and project level MRV frameworks for assessing impacts of adaptation strategies and mitigation targets, assessing NAMAS and REDD+ opportunities etc.

Setting up monitoring and evaluation framework: Monitoring and Evaluation (M&E) of climate change initiatives will play a key role in measuring the success of the strategies to adapt to climate change, undertaken by the state in the various sectors, that will be over and above the measures implemented to achieve its developmental targets. M&E of adaptation strategies at regular intervals will offer opportunities for course correction in case the M&E

criteria indicate mal-adaptation. The M&E indicators can be set to assess the adaptation achievement envisaged at the sectoral level, programme level or the project level. However, it is important to set the criteria in such a way so that it is able to distinguish climate change adaptation from adaptation due to developmental activities and autonomous adaptation as a response to climate variability.

M&E in the mitigation sector, however, will directly measure the results set out to be achieved in term of GHG reduction targets, energy efficiency targets, targets for increasing renewable energy in total energy mix so on and so forth and also offer opportunities for course correction if the targets set out to achieved are not being realized.

The M&E for ensuring climate proofing of sectors, programmes and projects can be carried out by trained staff in a climate change cell which the state will need to establish.

Building institutional capacities to integrate climate change concerns in development: This would mean developing capacities in institutions to review and hence redesign or bring in new developmental policies and programmes that would be able to identify the climate change signals, identifying the likely impacts and hence the vulnerabilities, and insert strategies into programmes or develop new programmes that would increase the resilience of the systems and facilitate coping with the adverse impacts of CC. Similarly mitigation planning would require, an understanding of the long term goals of the UNFCCC, India's position, and how India is setting its voluntary targets of reducing energy intensity and hence GHG emissions in the future. Translation of these global objectives into local state action would be a challange.

The basic steps towards integrating Climate adaptation into planning at sectoral policy, programme, project and action level would include:

- Applying a climate lens to identify the relevance of climate change to a policy, programme, plan or project.
- Interpreting climate data from different standard climate data sources.
- Assessing vulnerability for identifying factors contributing to vulnerability in a system.
- Identifying adaptation options from a range of adaptation options to adjust or improve planning and management.
- Selecting adaptation measures by evaluating priorities and prioritize options using selected criteria.
- Developing an M&E framework for monitoring and evaluation of adaptation options
- Identify institutional capacity requirements for adaptation and Identify institutions with such capacities, if absent build capacity to deal with adaptation as a continual change process.
- Assessing local climate stresses, vulnerability, resilience for local information on climate change vulnerability.

- Implementing action at local level and beyond: Identify action at the local level and how it links to sub-national, national and other actors and
- Integrating adaptation into the project cycle: Identify key steps to integrate adaptation according to the various steps of the project cycle.

To build the institutional capacities, it is suggested that other than the establishment of the Climate change focal point in the Government, each line department, needs to have a climate change call, which will ensure the application of the climate change lens in all its ongoing and future programmes. The Climate change cell in each department will liase with the Climate Change Focal Point for guidance as well as approval of programmes for ensuring climate proofing.

Seeking finance for adaptation and mitigation: Financing is a key element for a successful implementation of Adaptation or mitigation strategies. Funds that have been approved for the 8 missions of the National Action on Climate Change from the Planning Commission, most likely will remain the key source for adaptation and mitigation funding in India for the different states. Possibility of availing funds jointly with the central government can be explored from the Green Climate fund to be operationalised by the UNFCCC for supporting actions towards low-emission and climate-resilient development. Further, mechanisms can be developed to institute green tax in the state, on certain sectors (e.g inter state transport, electricity generation) that are highly fossil fuel intensive, and channelize these funds for additional mitigation actions. For pilots, funds can be explored through bilateral mechanisms and for large scale implementation loans from banks including multilateral banks may be sought.

1. Introduction

As per the 4th Assessment Report of the IPCC, warming of the climate system is unequivocal and is attributed mainly to anthropogenic activities (Box 1.1). In the past century, the Earth has warmed on an average by 0.76 °C and the rate of warming is increasing. According to WMO, the year 2010, was the warmest year on record. The Global average temperature in 2010 was 0.53 degrees Celsius above the average level during 1961-90, and it is higher than the two previous warmest years 1998 and 2005 in the last decade.

Box 1: The IPCC

During the course of this century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate and change in other global change drivers (especially land use change and overexploitation), if greenhouse gas emissions and other changes continue at or above current rates. By 2100 ecosystems will be exposed to atmospheric CO_2 levels substantially higher than in the past 650,000 years, and global temperatures at least among the highest of those experienced in the past 740,000 years. This will alter the structure, reduce biodiversity and perturb functioning of most ecosystems, and compromise the services they currently provide.

Source: IPCC 4th Assessment Report, The Scientific Basis of Climate Change, 2007.

The sea level is also rising. Global average sea level rose at an average rate of around 1.7 ± 0.3 mm per year over 1950 to 2009 and as per a satellite-measured average rate the rise was about 3.3 ± 0.4 mm per year between 1993 and 2009. Similarly, extreme weather events and their intensities have increased and regional climate patterns are changing. Climate change models, driven by a variety of socio economic scenarios project that the global average temperature may rise by 1.8 to 4.0°C by 2100.

At India level, the annual mean temperature of the country for the period 1901-2009, as whole has risen by 0.56°C (*IMD, 2010*) and by 2050s the temperature is projected to rise by 2-4°C (*NATCOM, 2004*). Further, the MoEF, GOI report focussing on 4 climate sensitive regions of India (*INCCA , 2010*), projects that even by 2030's the annual mean surface air temperature may rise by 1.7°C to 2.0°C with respect to current climate base line (1960-1990).

Climate change, as some of the studies suggest (*NATCOM, 2004; INCCA, 2010*), may alter the distribution and quality of India's natural resources, enhance water insecurity, reduce agriculture productivity, enhance exposure to extreme weather events, and pose even unforeseen health risks. This in turn is most likely to adversely affect development of the economy that is closely linked to the natural resource base. Consequently exposing majority of its population thriving on climate sensitive livelihoods such as agriculture and forest products are subjected to great risk.

In view of the requirement of a strategy to adapt to climate change that would ensure and enhance ecological sustainability and explore solutions towards more efficient technologies, the National Action Plan on Climate Change (NAPCC) was formulated and launched by the Prime minister in June 2008. It has eight missions that focus on

- Enhancing energy efficiency;
- Increasing the penetration of solar photo-voltaics and solar thermal in the total energy mix;
- Developing climate friendly sustainable habitats;
- A water mission for integrated water resources management;
- A mission on sustainable agriculture for making it more resilient to climate change;
- A green mission for enhancing ecosystem services of forests and for enhancing its C sequestration capacity;
- A mission on Himalayan ecosystem for sustaining and safeguarding the Himalayan glacier and mountain ecosystems; and the last mission is aimed towards
- Developing strategic knowledge base to address the concerns of climate change.

For translating national policies into action, especially at sub regional level within India, and decentralizing NAPCC objectives into local context, a territorial approach is necessary. It is in this context, it was felt necessary that the states should develop their prioritised action plan vis a vis their respective climate change concerns under the overarching objectives and missions of the National Action Plan on Climate Change. This also provides an opportunity for identifying the risks and opportunities of climate change, mainstreaming the climate change concerns by introducing low C climate resilient developmental activities in the state and generate pipeline investment ready initiatives that can be directly adopted

2. The Process of Preparation

Towards the preparation of the State Action Plan for Climate Change, the Government of West Bengal first organised a scoping workshop on March 15, 2010. The workshop was organised by the Department of Environment, Government of West Bengal, which is the nodal agency for climate change matters in the government. The workshop was chaired by the Chief Secretary, Government of West Bengal. The Chief secretary welcomed the move, as he opined, that climate change is now staring us in the face, and each and every state in India needs to design strategies to mainstream climate change concerns in its planning and implementation of various developmental programmes to adapt to the adverse impacts of climate change.

All concerned line departments of the Government of West Bengal, the research community, and the non Governmental organisations participated in the workshop. Additionally, external agencies like DFID, GIZ, and the World Bank were invited, who shared with the audience their experiences and lessons learnt from the various climate change projects being undertaken by them in the state in collaboration with the government of West Bengal.

Presentations were also made by, Principal Secretaries of Department of Power; Department of Sundarban Affairs, Department of Science and Technology; Managing Director, West Bengal Green Energy Development Corporation, Joint Secreatry, Panchayati Raj highlighting the concerns of climate change in their respective areas. Shri Mr. Debal Ray, Chief Environment Officer, Department of Environment, who is also focal point, climate change, made a presentation to apprise the audience about the general scientific basis of climate change, the various projects that the government is doing on climate change in collaboration with some of the bi-lateral's, the different policies that the West Bengal government has so far adopted towards addressing climate change concerns. Finally he concluded his presentation with the steps that need to be taken to start the preparation of the State Climate Change Action Plan:

- Constitution of drafting committee
- Identification of state plan components
- Constitution of sector wise working groups comprising of line departments and experts
- Review of published literature
- Consultation with those involvement in drafting of State Action Plan / National Action Plan
- Identification of the strategies and studies to be carried out
- Finalizing of implementation mechanism.
- Synthesising the sectoral plans into Sate Action Plan

Following the workshop, the notification for the steering committee and the drafting committee was published on 12th April, 2010 and signed by the Governor of West Bengal (see Annexure A for the notification) and the list of members of the Steering commitee and Drafting Committee.

Next a meeting of the drafting committee was held to deliberate upon the sectors that need to be considered vis a vis their vulnerability to climate change. It was agreed by the members that the sectors thrust areas of State Action Plan should match as closely as possible to the 8 national missions and 24 other critical initiatives. Further it was also pointed out that some specific areas of vulnerabilities of West Bengal like Darjeeling Himalayas and Sundarbans should also be properly addressed. After thorough discussion, following sectors areas were identified for State Action Plan

- Water
- Agriculture, Horticulture, Fisheries, Animal Husbandry
- Health
- Forestry
- Energy Efficiency
- Non conventional Energy Sources
- Sundarban's
- Darjeeling Himalayas
- Habitat
- Institute for climate change studies.

Formation of sectoral committee's for preparation of plans relating to each of the above sectors were discussed. It was decided that the departmental representatives in the drafting committee would take a leading role in formation of the sectoral committees and preparation of sectoral plans.

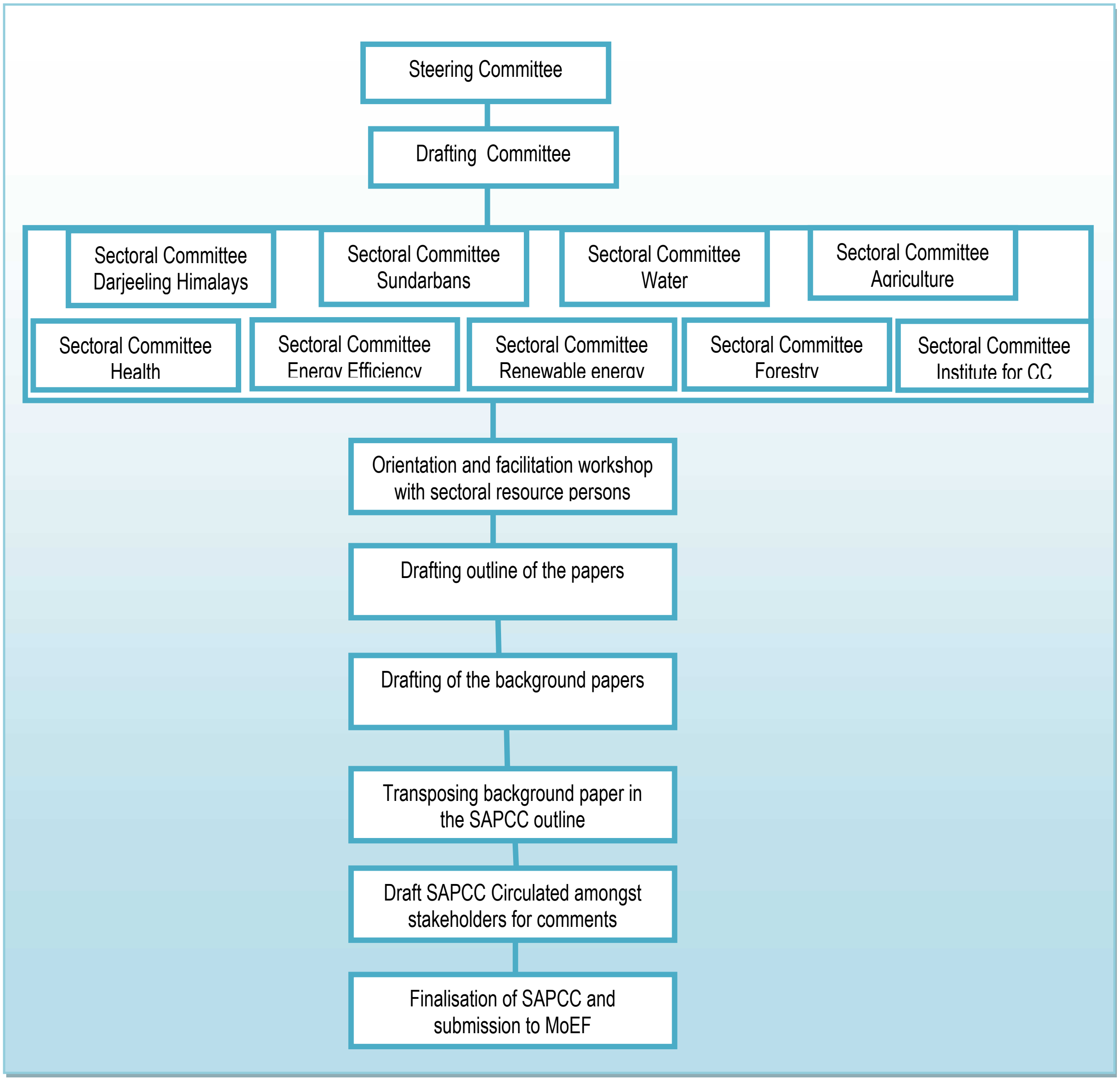
There after the notification for the formation of the sectoral committe's were published in December 2010 (see Annexure B) on Sundarbans and Energy efficiency on 16th and 24th Dec 2010. respectively. The committee's on Agriculture, water, health, habitats, institute for climate change, Darjeeling Himalays have been also constituted and brought out subsequently. The resolutions for which have also been passed.

A workshop was organised on 14th feb 2011, in the nature of orientation for the different working groups on NAPCC, guidelines for SAPCC, the vulnerability of the agriculture sector in West Bengal etc. A set of resource persons guided the participants to undertake in depth sectoral analysis where by they were able to identify key priorities and formulate adaptation strategies. The resource persons in these workshops were nationally recognised sectoral experts, who were also available for guidance towards prioritisation of strategies and development of the action plan. The outcome of this workshop lead to the formulation of the outline of the working papers.

Further, extensive consultations within the working group members and other concerned stake holders carried out. Based on these steps, the sectoral papers were drafted, by the members of the working groups, which formed the basis of the SAPCC. The sectoral papers, focussed on identification of sectoral concerns due to climate change, did a review of ongoing programmes in these sectors which are also towards climate proofing and the institutional mechanism through which these programmes are implemented. identified the strategies for climate proofing the concerns and identified the implementable actions on the 12th and 13th plan. The papers also made an assessment of the cost of implementation of these actions at today's prices. The contents of the sectoral papers were transposed in line with the framework of the SAPCC provided by the Ministry of Environment and Forests. Next the draft SAPCC was circulated amongst all stakeholders for their comments.

The SAPCC was presented to the steering committee on 12th April, 2010. It has approved 6 sectors and those are being presented to the MoEF in the 1st phase by 25h April, 2011. The rest of the chapters on Habitats, Sundarbans and Darjeeling Himalayas have now been completed and included in this 2nd version.

Figure 2.1: Steps of Preparation of WB-SAPCC

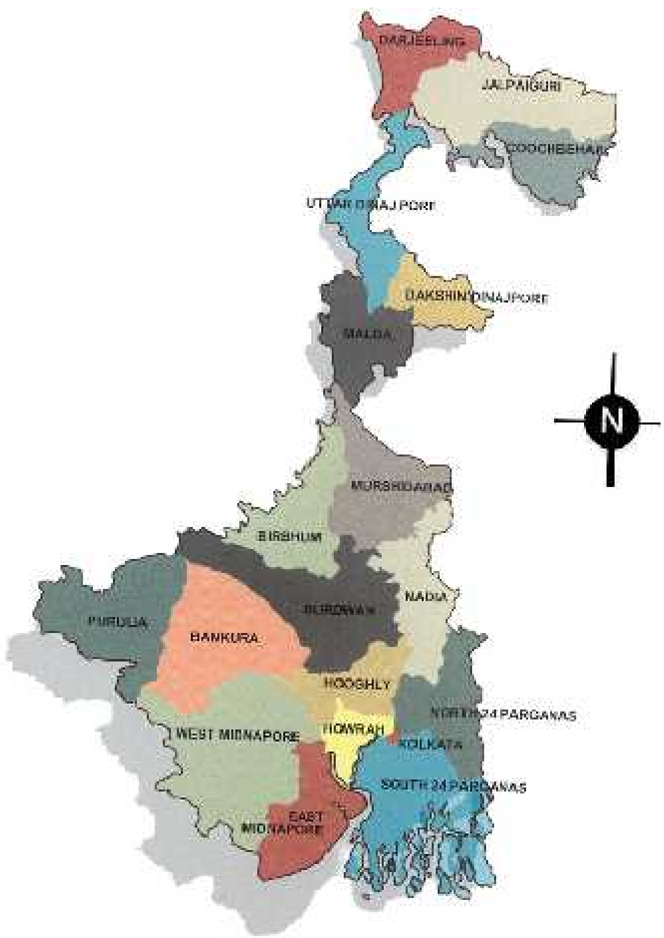


3. West Bengal State Profile

Physiography

The State of West Bengal is situated in the eastern part of the country between 21°20' and 27°32' N latitude and 85°50' and 89°52' E longitude. The total area of the state is 88,752 sq km which is 2.7% of the total area in the country. The state has two distinct natural divisions - the Northern Himalayan region and the Southern Alluvial plains. In the north three main rivers, anmely, Teesta, Torsa, and Jaldhak flow which are tributaries of Bramhaputrs. The other two important rivers pasing through the state are Ganga and Hooghly. The Ganga drains into the Bay of Bengal forming the famous delta of Indian sundarbans.

The state has many shallow marshy depressions which are the relatively unfilled parts of ancient topographic formations. These are subjected to annual inundation during the monsoon months, having in many instances permanent wetlands in their shallowest parts. In addition to all these, there are many types of landforms flanking the northern Himalayan mountain as also the western Deccan plateau within West Bengal which had developed originally by the sediments brought by rivers in the ancient geological periods. Many of these are now suffering from erosion.



On a physiographic basis the state can be divided into four physiographic divisions, namely, the Himalayan Region; Eastern fringe of Chotanagpur Plateau; the Deltaic Zone and the Alluvial Plains Remaining areas of the State.

The State has international borders with Bangladesh, Nepal and Bhutan while it shares national States boundaries with Sikkim, Assam, Bihar, Jharkhand and Orissa. In its south lies the Bay of Bengal. West Bengal has 19 districts (see figure along side). On the basis of distribution of climate and soil, the agricultural feasibility of the state is harnessed from 6 distinct agro-climatic zones, and they are the

- Hill region: Covering the districts of Darjeeling district, Coochbehar and Jalpaiguri
- Old Alluvial Zone: Comprising of North Dinajpur, South Dinajpur and Malda

- New Alluvial Zone: Covering Murshidabad, Nadia, 24 N. Parganas, Hooghly and Burdawan a
- Red and Laterite zone: Covering the districst of Birbhum, Bankura, Purulia, West Medinipur;
- Saline Coastal region: Covering East Medinipur, Hooghly, 24 South Parganas, Kolkata

Climate

The climate of the State is tropical and humid except in the northern hilly region which is close to the Himalayans. The temperature in the mainland normally varies between 24°C to 40°C during summer and 7°C to 26°C during the winter. The average rainfall in the State is about 1750 mm with considerable variation among the districts ranging between 1234 mm in Birbhum to 4136 mm in Jalpaiguri.

Demography

The estimated population of West Bengal in 2009 was 87.8 million and has become 91.3 million as per the latest Census of India carried out in 2011. The decadal growth rate for the period 2001-2011 has been 13.93% which has decreased from 17.77% estimated for the period 1991-2001.North twenty four Pargana's has the highest population of 8.9 million and the most dense is the population in Kolkata with 24252 people/sq km (Source:http://censusindia.gov.in/2011-prov-results/prov_data_products_wb. html, http://www.westbengalforest. gov .in/publication_pdf /StateForestReport_ 2008-2009.p.pdf). The Sex Ratio of the State stood at 934 in 2001 as against 933 at

Table 3.1: Key features of the state

Geographical Area	**88,752 sq. km.**
Number of Districts	19
Number of Blocks	341
Population	91.35 million*
Rural Population	65,5 million**
Urban Population	25.8 million**
Population Density	1029 per sq. km*
Per capita agriculture land holding	Less than 1 ha*** (about 0.64ha)
Fertility rates	1.9, 2.1 as of 2007***
Birth rates- rural, urban	19.4, 12.4 per thousand (2001 census)
Death rates - rural, Urban	6.1, 6.6 per thousand*** (2001 census)
Infant mortality rates	37, 29 per thousand*** (2001 census)
Normal Annual Rainfall	1,234 - 4,136 mm.
Cultivable Area	56.84 lakh ha
Net Sown Area	54.65 lakh ha***
Net Cropped Area	52.56 lakh ha. ***
Cropping intensity	181% ***
Area under Forest	11897 sq km****
Surface Water Resources	132.90 lakh ha. m*****
Annual Replenishable Ground Water	30.36 lakh ha. m.
Ultimate Irrigation Potential	70.00 lakh ha.
Total Flood Prone Area	37,660 sq. km.
Coastal Length	280 km.

Sources: *Census, 2011, **estimated for 2011, using 2001 ratio, ***WB economic review 2009-2010, * State of forest report, 2008-2009, ****Irrigation***

national level. The Sex Ratio in West Bengal had been steadily increasing during last five decades after Independence whereas at national level it registered a decreasing trend during this period. The rural and urban population, is

Water Resources

West Bengal is endowed with 7.5 per cent of the water resource of the country. Main source of water in West Bengal is rain fall, the annual average receipt of which is around 1762mm. Of this 76% is received in the monsoon months and the rest in the non monsoon period. 21% of the rain fall infiltrates through the soils and recharges the ground water and 49% goes back to the atmosphere as evapo-transpiration. The net annual water resource generated from rainfall in West Bengal amounts to 51.02 bcm (WBPCB, 2009). About 60% of the water resource is available in the North and South Bengal has 40% of the resources. The replenishable ground water resources including natural discharge is 34.20 bcm of which 31% is in north Bengal and 69% in South Bengal. The state receives 598.56 bcm of trans boundary water from neighbouring states. The Ganga carries 525 bcm of water from its large catchment covering 26% of the Indian geographical area.

Biodiversity and Forests

The climate and physiography of the state supports a huge diversity of life forms. Covering just 2.7% of the Indian landmass it is home to 12.27% of Indian biodiversity known till date. The state has more than 7000 species of described flora including bacteria, algae, fungi, bryophytes, pteridophytes and angiosperms and more than 10,000 species of described fauna. The forests of West Bengal are classified into seven categories *viz.*, Tropical Semi-Evergreen Forest, Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Littoral and Swampy Forest, Sub-Tropical Hill Forest, Eastern Himalayan Wet Temperate Forest and Alpine Forest. The state has a recorded forest land of 11,879 sq. km., of which 7,054 sq. km. is Reserved Forest, 3,772 sq. km. is Protected Forest and 1,053 sq. km. is Unclassified State Forest, thus constituting 13.38% of the geographical area of the state. Under the conservation and protection regime the State has one Biosphere Reserve, two Tiger Reserves, five National Parks and 15 Wildlife Sanctuaries.

Economy

As of 2008-2009, the Net State Domestic Product (NSDP) of the climate dependent sectors namely, agriculture including animal husbandry and horticulture, forestry and fisheries together was 22.11% of the total NSDP at Constant 1999-00 Prices, that is a quarter of the total NSDP of the state of West Bengal which is generated by 70% of its total population, mainly rural. Of the total rural workers, 19.53% and 19.30% are cultivators and agricultural labourers, respectively, while 4.72 percent are engaged in household industries. According to the Planning Commission, 31.85% of the total population lived below poverty line in 1999-2000. The detailed NSDP of the sate by sector is presented in Table 3.2

Table 3.2: Estimates of Net State Domestic Product in Crores by Industry of Origin at Constant 1999-00 Prices

Sl. No.	Industry	2007-08 (P)	2008-09 (Q)	% Change
1.	Agriculture	40862.44	40085.53	-1.90
2.	Forestry	1838.01	1909.89	3.91
3.	Fishery	5692.30	5829.08	2.40
4.	Mining & Quarrying	1804.41	1841.98	2.08
	Primary	**50197.16**	**49666.48**	**-1.06**
5.	Manufacturing	16083.49	16005.47	-0.49
5.1	Manufacturing (Regd.)	5957.24	6026.96	1.17
5.2	Manufacturing (Unregd.)	10126.25	9978.51	-1.46
6.	Construction	17194.19	20212.93	17.56
7.	Electricity, Gas & Water Supply	1627.97	1707.19	4.87
	Secondary	**34905.65**	**37925.59**	**8.65**
8.	Transport, Storage & Communication			
8.1	Railways	3287.07	3575.97	8.79
8.2	Transport by other means & Storage	9445.24	9672.25	2.40
8.3	Communication	6386.57	8114.64	27.06
9.	Trade, Hotel & Restaurants	33608.56	34444.89	2.49
10.	Banking & Insurance	16205.03	18856.49	16.36
11.	Real Estate, Ownership of Dwelling & Business Services	22918.52	26275.97	14.65
12.	Public Administration	7492.67	8070.04	7.71
13.	Other Services	18819.08	19713.66	4.75
	Tertiary	**118162.74**	**128723.91**	**8.94**
	Total	**203265.55**	**216315.98**	6.42
	Per Capita Income (Rs.)	23455.79	24720.13	5.39

P : Provisional estimates & Q : Quick estimates.

Source: Bureau of Applied Economics & Statistics, Govt. of West Bengal.

4. Observed Changes in Climate and Climate Projections

Observed Climate

Temperature: Data used for this analysis includes the IMD gridded maximum and minimum temperature at 1° spatial resolution for the time period 1969-2005 (37 years). According to the observations during this period, the maximum temperatures are decreasing across the state whereas the minimum temperatures are increasing (Figure 4.1). The maximum temperature has decreased by -0.5°C with respect to starting of the observation period (1970s) in the New Alluvial zone, the laterite zone and the Saline coastal zone. In the Hilly, Terai and the old alluvial zone, the maximum temperature has also decreased but by only -0.25oC. Whereas the minimum temperatures are increasing all across the state. In the laterite zone, the minimum temperature has increased by 0.5°C, in the Hilly, Terai and the old Alluvial zone, the temperatures have increased by 1.5°C and in the new alluvial zone and the coastal zone the minimum temperatures have increased by 1°C.

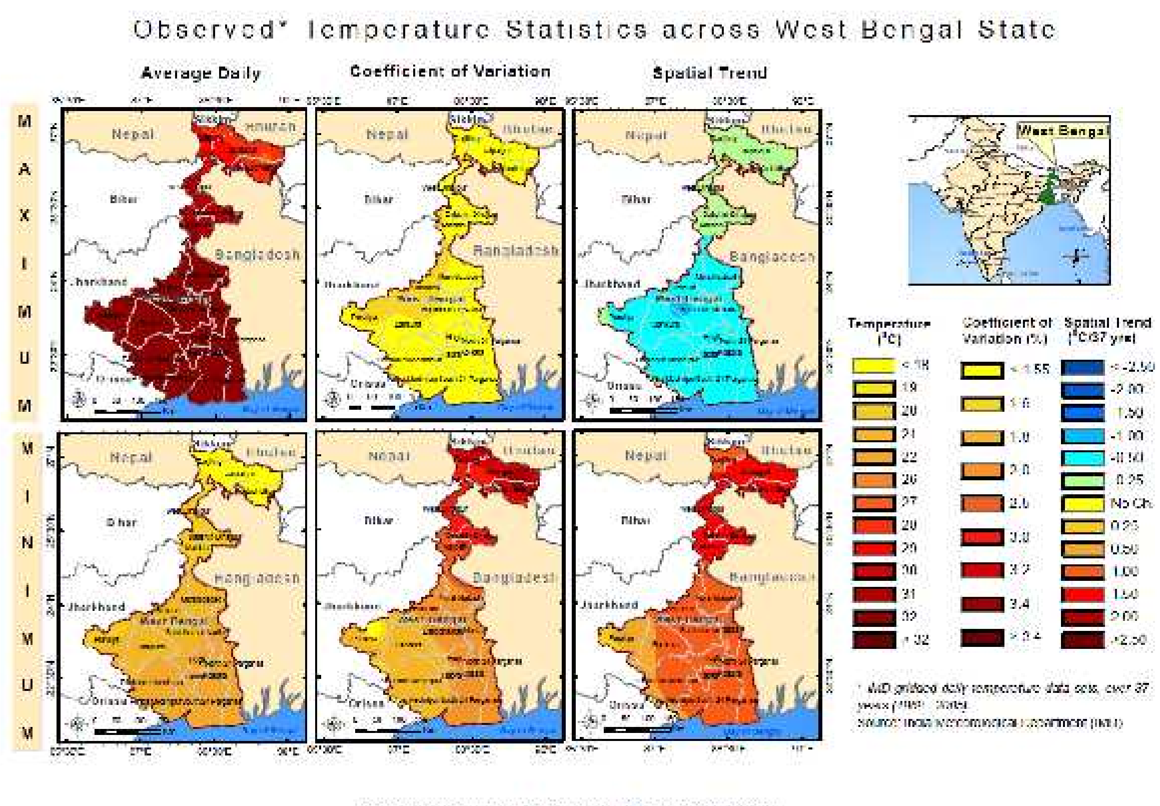


Figure 4.1: Observed changes in minimum and maximum temperatures in West Bengal

Observed changes in Precipitation: There is high spatial variation in changes observed in rainfall between 1971-2005 (See Figure 4.2). There is a clear increasing trend in observed rainfall in the northern region above Birbhum upto Darjeeling Himalayas and in the Sundarban region. No changes are observed in some pockets in the eastern Himalayan region that falls within Coochbihar and in the southern region below Dakshin dinajpur and in in Southern Purulia and in the South Medinipur areas. The postmosoon rainfall shows an increase almost all over West Bengal except in the eastern Himalayan region in the state, in North Dinajpur and in Western Purulia. In the winter period in Jan and Feb, there is a general decrease in rain fall in the Southern region of the state, with no change in parts of Medinipur and in Darjeeling Himalayas. In the March to April period, there is an increase in precipitation in central part of the Southern region of West Bengal covering Burdawan, Bankura, parts of Medinipur and Sundarban areas. No change is observed in the eastern parts of Sundarbans, and distinct decrease in Murshidabad, Birbhum and Nadia.

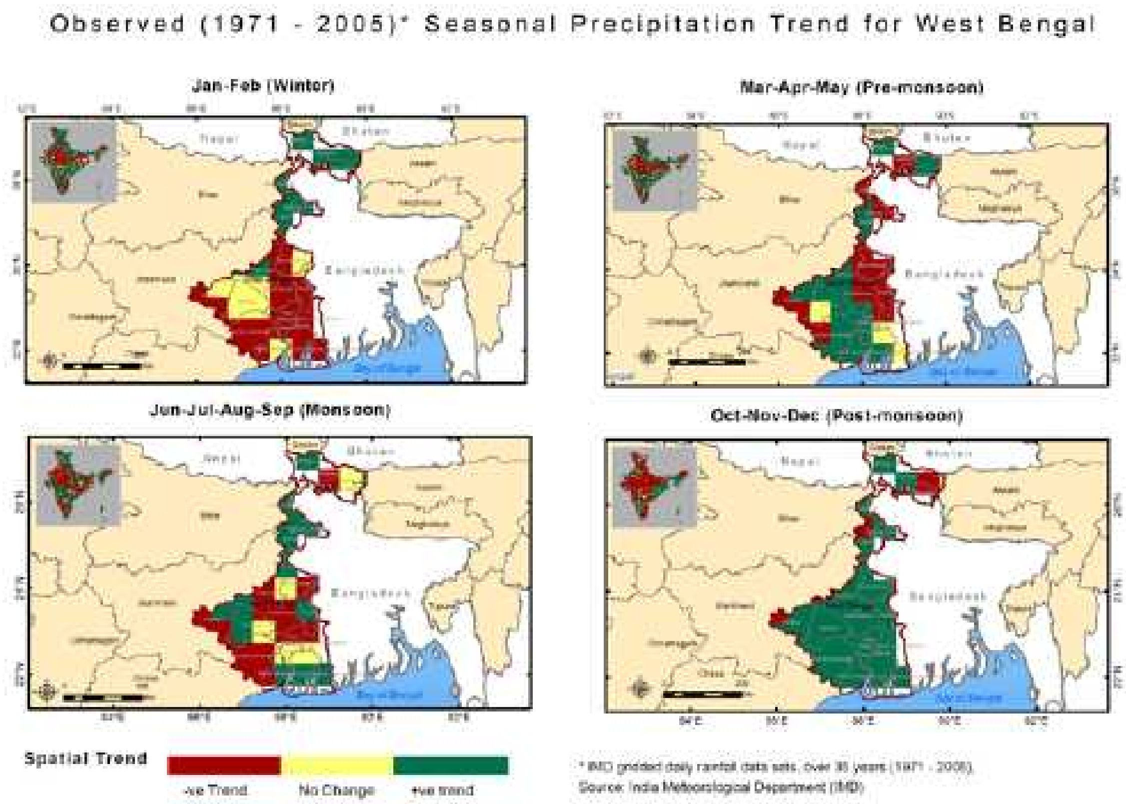


Figure 4.2: Observed changes in precipitation between 1971-2005.

Onset of Monsoon: The maximum delay in onset of monsoon is 11 and 7 days over Andaman & Nicobar Islands during 1941 – 1970 and 1971 – 2000 respectively. For India as a whole, the commencement of onset starts from Andaman & Nicobar Islands. The mean withdrawal dates are found to be later than the existing normal, in both the 30 years slot of 1941 – 1970 and 1971 – 2000, by about one to one and a half week. A general late onset, as concluded earlier coupled with late withdrawal suggests a shift in the monsoon activity.

Cyclones and Storm surges: Long term observations between 1900-2008 show an increasing trend in the frequency of tropical cyclonic storms (48-63 kts or 88-117 kmph) as well as formation of severe cyclonic storms (64-90 kts or 118-167 kmph) in the Bay of Bengal during the period 1900-2008 (figure 4.3). Further, Storm surges form when heavy winds produced by tropical cyclones generate the disturbances in the ocean. As these surges propagate into the shallow regions, they amplify and produce large variations of sea level at the coast. The height of the storm surge depends on wind speed, the shape of the coastline, and variations in the water depth along the coastline. Height also depends on phase of the tide. If a surge occurs during high tide, the storm surge will be higher than if it occurs during low tide. Category 5 tropical cyclones can produce storm surges in excess of 6m (20 feet). Because the storm surge occurs ahead of the eye of the storm, the surge will reach coastal areas long before the cyclone makes landfall.

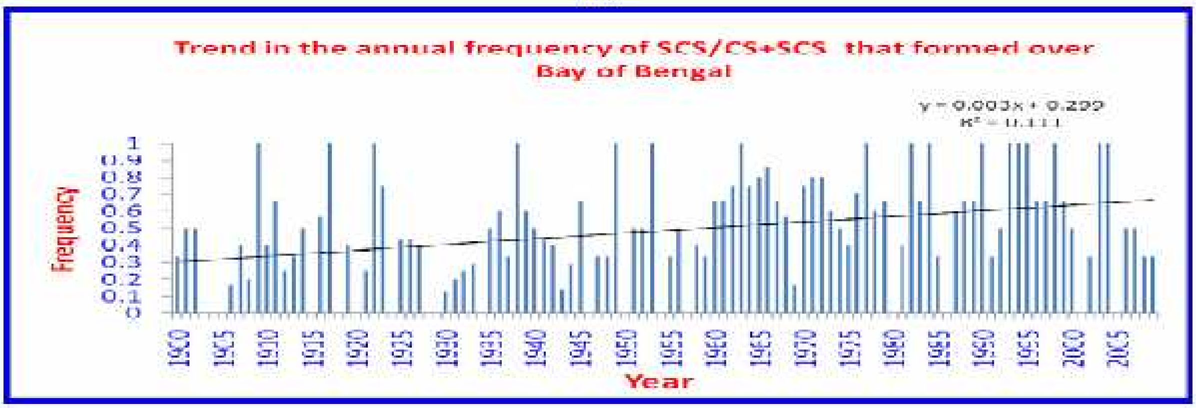


Figure 4.3: Increasing trends of severed cyclonic storm over the region of Bay of Bengal
Source: IMD, 2010

Mean Sea Level rise: The average sea level rise has been 1.3 mm per year along the Indian coast, however, tide gauge observations at the diamond harbor port indicate a sea level rise of 5.7 mm, which can be attributed to subsidence in the region at the rate of 4mm per year (INCCA, 2010).

Presently the State is facing inadequate and erratic rainfall in successive years mainly in South Bengal Districts. Further, more than 80% of annual precipitation occurs during monsoon and that too erratically in respect of time and space causing drought like situations in summer and flood during monsoons. The onset of monsoon is delayed. There is an overall warming with minimum temperatures increasing faster than the maximum temperatures. Cyclone frequency of severe cyclonic storms is increasing over Bay of Bengal and the sea level is rising globally, however, the level of rise is higher across coast line of West Bengal, mostly due to subsidense of the land mass near the coast and also may be due to devlopmental activities, leading to submergence of islnads in the eastern region of the coast.

Increased population and immense pressure on land compels the State for judicious use of water resources which becomes very scarce in non-monsoon months. Due to non-availability of adequate surface water resources in non-monsoon months and degradation of many of the surface water bodies due to siltation, dependence on ground water for drinking as well as for irrigation are rapidly increasing with results in consequent depletion of ground water level. So, creation of additional storage and demand side management are dual challenges of present water management.

Climate Change Projections

Climate projections for 2050s and 2100 have been derived from PRECIS (Providing Regional Climate for Impact Studies) is the Hadley Centre portable regional climate model, developed to run on a PC with a grid resolution of 0.44° x 0.44°. PRECIS simulation datasets is provided by the Indian Institute of Tropical Meteorology, Pune. The climate change scenarios are driven by the GHG emission scenarios -IPCC A1B which assumes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and assumes rapid introduction of new and more efficient technologies.

Rainfall: Projections of rain fall in West Bengal for mid century (2050s) indicates that there is a decrease in winter rain fall in the coastal zone and the lower part of the new alluvial zone, and no change is indicated in the rest of the zones, except that again a decrease in precipiation is observed in the eastern part of the terai zone. In the monsoon period, in 2050s, an increase in precipitation is projected for all the regions, except for the eastern part of the coastal region and western part of the red and laterite region (Figure 4.4, upper panel). In 2100, however, significant increase in precipitation is observed in winters in the terai, hill and the new alluvial zone, with the lower zones receiving a slightly more rainfall with respect to base line.

Temperature: As regards temperature, in 2050s, the average daily maximum and minimum temperatures are both projected to rise by 2.2^{o}C in 2050s and by 2100, the temperatures are likely to rise by 3.6 to greater than 5^{o}C celcius with respect to the base line i.e 1960-1990 (see Figure 4.5).

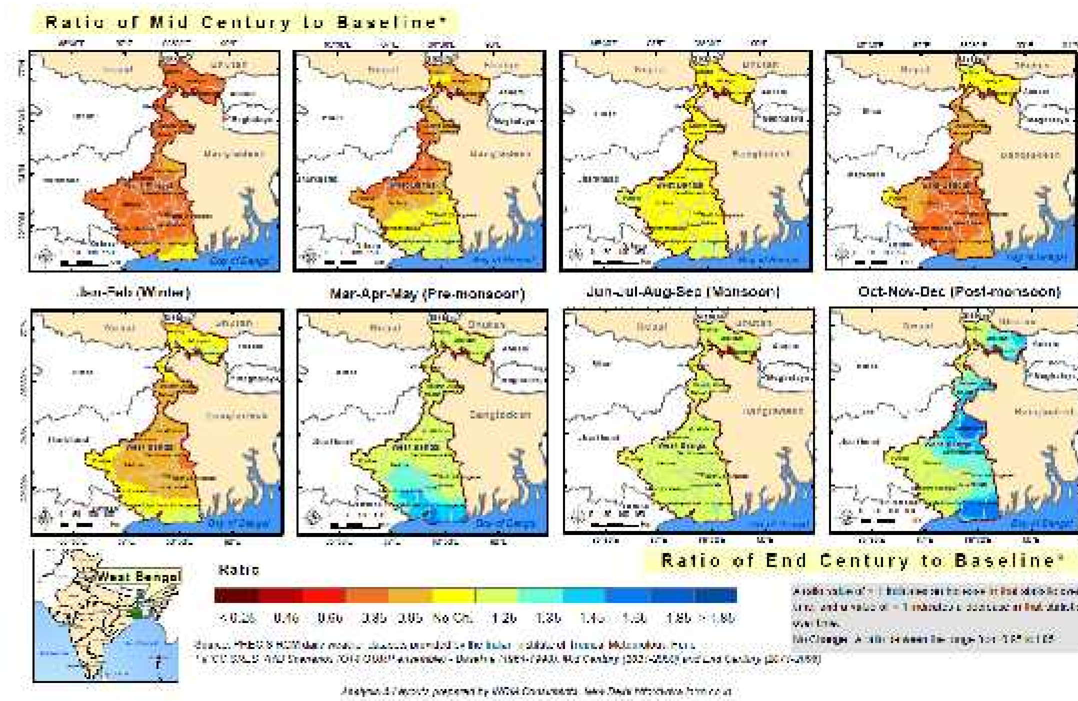


Figure 4.4: Projected changes in average rainfall during Winter, pre-monsoon, Monsoon and post monsoon season in West Bengal 2050s (upper panel) and in 2100 (lower panel)

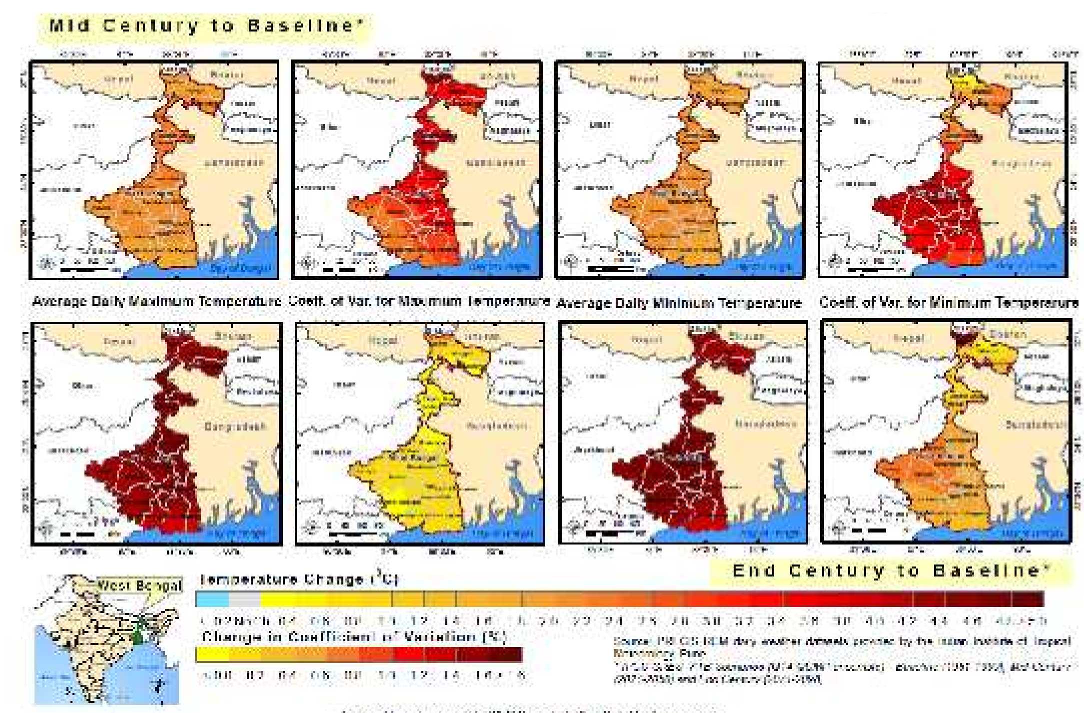


Figure 4.5: Projected changes in temperature in 2050s (upper pane) and in 2100 (lower panel)

5. Water Resources

Introduction

Extending from the Himalayas in the North to the Bay of Bengal in the south, West Bengal offers wide topographic diversity and intricate drainage network of 22 basins (see figure 5.1a). Monson rainfall is the mainstay of water in these basins, though some part of the water in these basins also come to the state from transnational locations such as Nepal and Bhutan and across interstate borders via Ganga , Teesat and through tributaries of Brahmaputra.

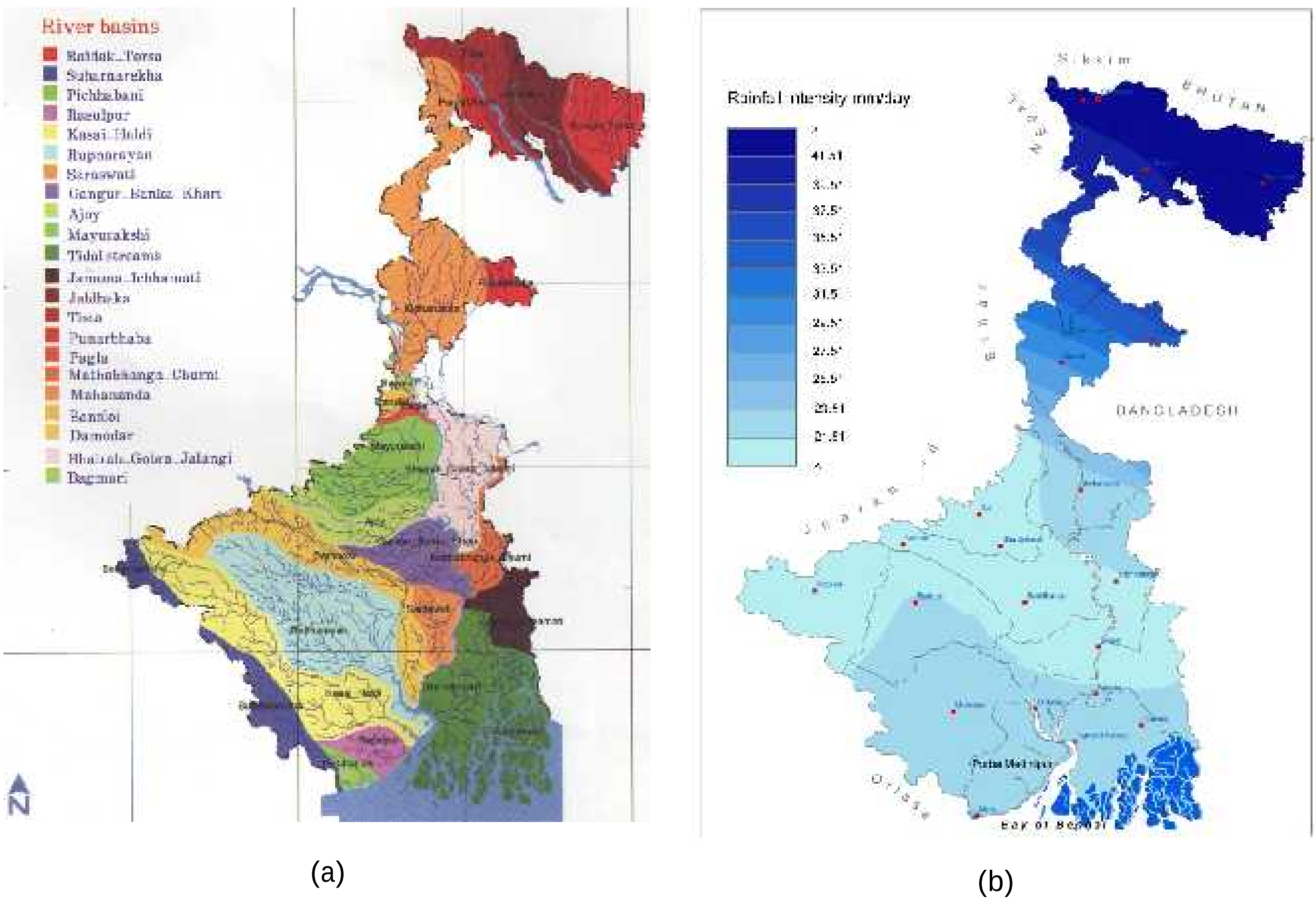


Figure 5.1: (a) Drainage basins of West Bengal, (b) Rainfall intensity across West Bengal

There are two hubs in West Bengal, namely, North Bengal and South Bengal divided by river Ganga that receive distinctly variable rainfall. The rainfall intensity in North Bengal extending from Darjeeling in the north to Maldah district in the south, varies between 25.51 mm/day to greater than 44.51 mm/day. In the southern region, the rain fall intensity varies between 25.51 mm/day to less than 21.51 mm/ day (see Figure 5.1b). About 60% of the surface water and 28% of the ground water in West Bengal is available to North Bengal that supports only

18% of the population of the region. Where as 82% of the population residing in South Bengal depends only on 40% of the surface water and extracts 78% of the total ground water for its needs.

Table 5.1: Water resources in different districts of West Bengal

	Monsoon rain fall (mm)	Non monsoon rainfall (mm)	Surface water (BCM)	Ground water (BCM)	Trans boundary water (BCM)	Per capita water availability as of 2001 CM/ capita
Darjeeling	2224.0	527.8	5.78	0.52	16.25	3945.32
Jalpaiguri	2471.3	604.8	11.30	2.64	32.56	4130.27
Koch Bihar	2604.0	667.6	6.42	2.32	44.18	3552.65
Uttar Dinajpur	1902.3	504.6	3.31	1.68	16.86	2059.38
Dakshin Dinajpur	1469.9	458.4	1.55	0.95	18.64	1676.0
Maldah	1307.7	407.1	2.14	1.40	553.21	1084.15
Murshidabad	1167.4	385.6	0.54	2.52	561.88	525.63
Birbhum	1143.0	384.3	1.46	1.67	4.50	1047.02
Nadia	1175.3	432.2	-0.27	2.17	48.25	415.8
Bardhaman	1174.0	425.6	1.84	3.34	45.54	757.02
Bankura	1159.7	387.5	2.06	2.09	13.35	1309.8
Purulia	1163.0	344.3	3.68	0.77	9.69	1767.9
Paschim Medinipur	1218.9	441.9	2.36	3.82	3.61	1199.1
Purba Medinipur	1240.3	457.6	3.27	0.83	76.68	820.5
Haora	1240.5	451.2	0.96	0.37	67.36	313.6
Hugli	1208.2	441.4	0.59	1.70	65.28	457.6
Kolkata	1245.9	454.7	0.25	0.00	50.07	55.0
North 24 Parganas	1231.0	452.3	1.91	1.58	50.33	393.6
South 24 Parganas	1266.7	461.9	1.86	3.84	81.03	831.6
TOTAL[9]			51.01	34.21	1759.27	

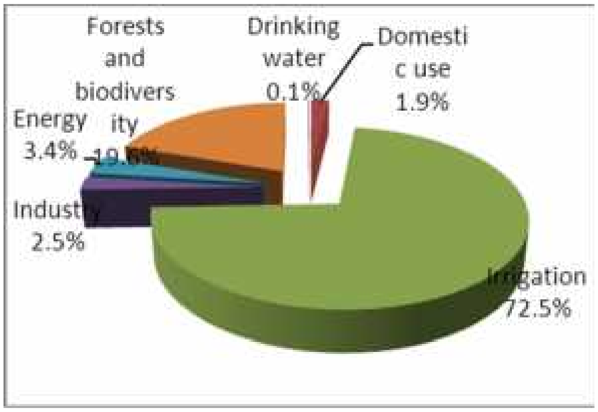
Key:

Water sufficient : >1600 cum/capita	Water Stress: 1000-1600 cum/capita	Water scarcity: 500-1000 cum/capita	Severe scarcity: <500 cu m/capita	Districts experiencing annual water deficit with respect to total average receipt of rain fall

Source: Water Resources and its Quality in West Bengal, Status of Environment Report, West Bengal Pollution Control Board, 2009 (WBPCB, 2009).

[9] The totals for the surface water and ground water resources stated here as per WBPCB (*2009*) are at variance with the estimates indicated by the irrigation department in its 1987 estimates (*Report of Expert Committee on Irrigation, 1987*), as in this estimate only 75% of the average rain fall has been considered as assured availability keeping in view the uncertainties in the average annual rain fall over the years as against the total average rain fall considered in the earlier estimate.

demand which is dominating now may reduce over the years because as improved use of water and water conservation technologies may be practiced more and more in agriculture. The water demand in the forest sector is directly proportion to receipt of rain fall in forest areas. The present 14% of area under forest cover needs to ideally expand to 30% of the total area. Assuming that West Bengal will be able to achieve this target by 2051, the water demand for the forest sector is also likely to increase.



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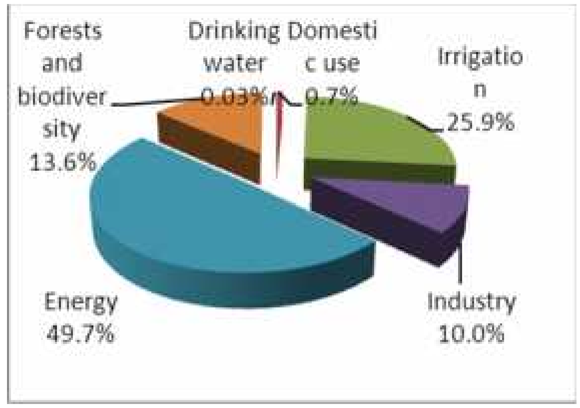


2051

Figure 5.2: Current and future water demand by sector in West Bengal
(Source: WBPCB, 2009)

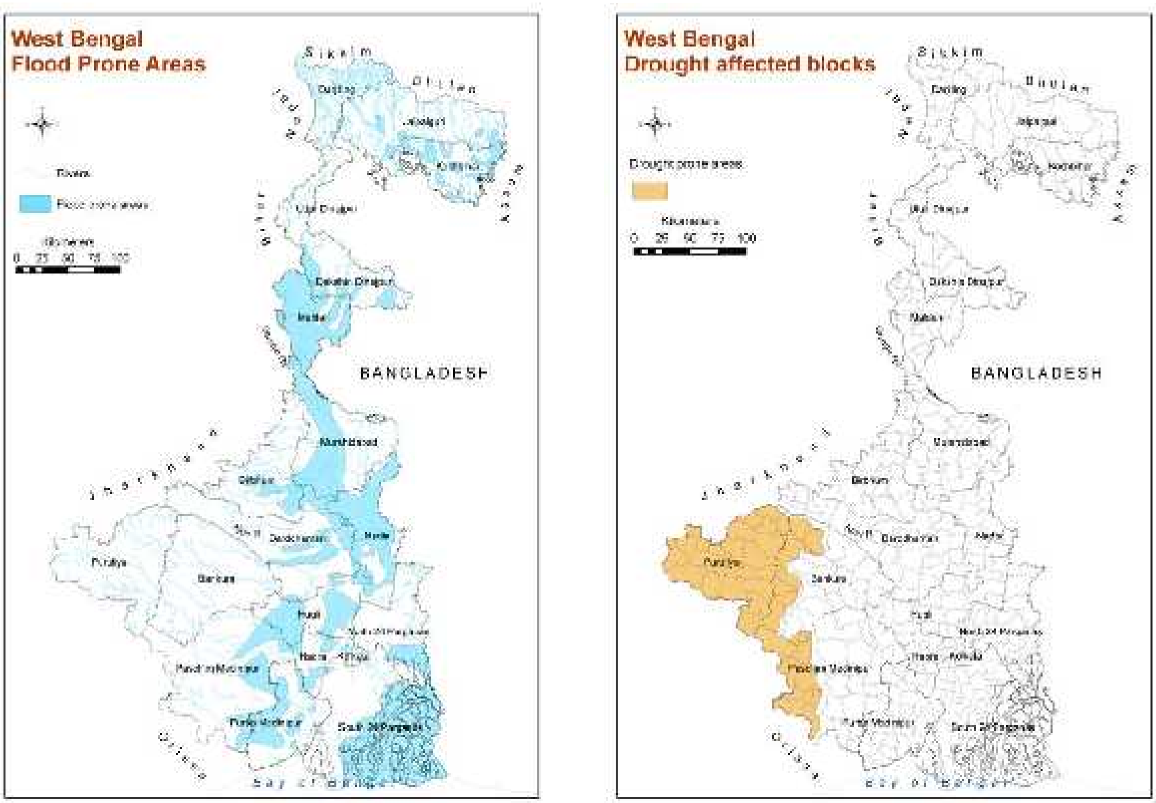
The census carried out in 2001 and the investigations of SWID (SWID,2001), has revealed that 91.4% of rural households and 41.2% of urban households rely on underground water in West Bengal. One in 5 rural households have to travel to more than 1/2 a km to access drinking water. one in 3 households in urban West Bengal do not have access to direct water supply. Currently, the districts of Bardhaman, Hugli, Purba Medinipur, and Haora, the rice bowl of West Bengal, experience an annual deficit of water availability for agriculture with respect to average rainfall receipt of these districts.

Extreme events

Floods: About 42% of the state area is flood prone (see figure 5.3a) and is manifested across the state by various modes. Floods can be due to excess water carried over from transnational and inter state borders. For example, floods are caused in north Bengal, by flood waters received through rivers Teesta, Torsa, Jaldhaka, Raidak from Sikkim and Bhutan. In Uttar and Dakshin Dinajpur by flood waters in rivers passing through these two districts and originating in Bangladesh. In Malda by flood waters received through Mahananda from Nepal, and through Ganga which carries flood water from about 11 States in India.

Extreme rainfall, relating to late monsoon cloud bursts also lead to floods here. The infrastructures such as roads and railways with inadequate culverts intercept cause expansion of floods. Poor drainage is also a cause due which the flood spreads. Case in point is the city of Kolkata, where a recent study (World Bank, 2010) has indicated that the situation in the city of Kolkata is critical, due to inadequate infrastructure, unplanned land-use, poor socio-economic and environmental conditions, and the inadequacy of the drainage capacity of the sewerage systems. These have been further aggravated by inadequate maintenance as well as the siltation of the existing trunk sewer systems that have considerably reduced their carrying capacity. While the sewer networks in KMC under such partially silted condition still provide reasonable hydraulic capacity for carrying the dry weather flow, they prove highly inadequate for carrying the storm weather flow even with normal precipitation during the rainy season.

Also floods are caused by storm surges resulting from cyclones and sea level rise. The recent damages caused by the Cyclone Aila, has established, that the southern Coastal region of West Bengal, covering the southern part of South 24 Pargana district, is extremely vulnerable to storm surges and cyclones. The soil in this region has become saline due to this event even upto a distance of 40 km from Kolkata and drinking water became contaminated with sea water. Additionally, the sea level rising in some areas of the coast at a much higher rate than the others is also a cause of inundation.



(a) (b)

Figure 5.3: (a) Flood prone areas of West Bengal. (b) Drought prone areas of West Bengal
Source: WBPCB, 2009

Droughts: Every summer many parts of Purulia, Bankura, Paschim Medinipur, and Birbhum (covering the south-western part of the state) suffer water shortage with respect to the entire state (Figure 5.3 b). The tradition of storage of water in ponds has slowly being forgotten. The governments efforts to supply water for drinking and irrigation is dependent on the reservoirs of Damodar valley Project, namely, Massanjore and Kansaboti. The storage capacity of these reservoirs have reduced over the years, mainly due to siltation rendering the region bereft of adequate water during summers. Also introduction of water intensive crops in the region, has lead to higher crop failures making the region and its people vulnerable. In 2010, the monsoon was weak over West Bengal, though it was strong all over India. These are such events, which the government need to be adequately prepared for in the future.

Landslides: Incessant rains and at times cyclones lead to land slides in North Bengal. Case in point is the impact of the latest super cyclone Aila in 2009. Water supply in these regions was affected severly during this event.

Water Pollution

The increasing exploitation of ground water exceeding replenishable limits has been causing irreparable damage and leading to arsenic and fluoride contamination in the eastern and western parts of West Bengal respectively (see figure 5.4 a and b) . The arsenic in ground water is spread over 81 blocks belonging to eight districts (Govt. of WB,2007) and about 225 villages in 43 blocks of 7 districts have been found to contain fluoride in ground water. Depletion of ground water is causing desiccation of rivers during non monsoon months, as the capacity for effluent seepage towards the river is reduced. Over dependence on ground water has lead to the decay of tradition of practicing lift irrigation. Further, inundation of land by sea water is causing salinity of water for drinking as well as agriculture.

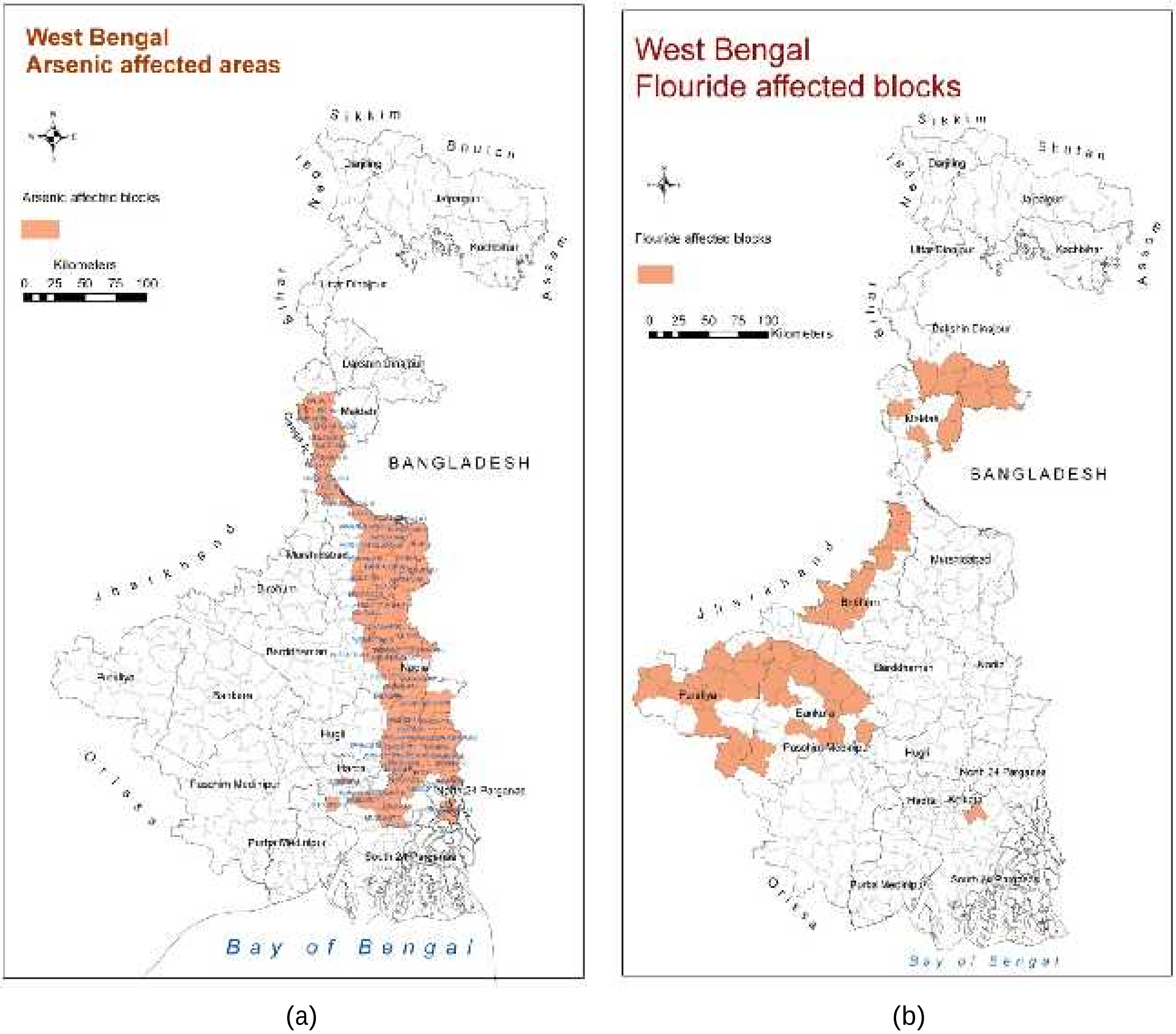


Figure 5.4: (a) Arsenic affected blocks, (b) Fluoride affected block

Source : WBPCB, 2009

Institutions Involved in Water Sector Service Delivery

Irrigation & Waterways Department: Harnesses surface water resources of the State through all forms of interception and facilitates the utilization of the same for different purposes. Looks after water resource management of all the river basins of the State other than Damodar.

Damodar Valley Corporation(DVC): DVC has a network of four dams - Tilaiya and Maithon on river Barakar, Panchet on river Damodar and Konar on river Konar. DVC dams are capable of moderating floods does water resource management to meet industrial, municipal and domestic requirements in West Bengal & Jharkhand. Also supplies irrigation water to the districts of Burdwan, Bankura & Hoogly. also supplies water for irrigation in upper valley through lift irrigation with the water available from check dams constructed by DVC.

Water Resource Investigation & Development Department: Water Resources Development Directorate is concerned with the implementation of minor irrigation schemes and State Water Investigation Directorate is concerned with the investigation of Ground water resources.

Public Health Engineering Department, Govt. of West Bengal: Public Health Engineering Department undertakes programmes of implementation of water supply and sanitation services.

Sundarban Development Board: Is entrusted with the development of the Sundarbans and in effect also develops water related infrastructure to meet water demand

Municipal Affairs Department, Govt. of West Bengal: Municipal Water Supply & Sanitation in Urban Areas.

West Bengal Pollution Control Board: Implementation of the provisions of Water Act, 1974 (Prevention and Control of Pollution).

Commerce & Industry Department, Govt. of West Bengal: Manages use of Industrial Water.

Current Programmes and Projects of the Government

To meet the water demand of different sectors and to arrest floods and water pollution issues, various policies and programmes and hence projects have been taken up by the government, which either flow directly from the central government policies and schemes or are state specific policies.

Irrigation Department: The irrigation and water resources department along with Damodar valley Corporation manages major irrigation projects. The irrigation department also develops and manages medium irrigation projects along with flood management works.

Major Irrigation Projects:

- Mayurakshi reservoir Project: Has an irrigation potential of 2,50,860 ha. Covers the districts of Birbhum, Murshidabad, and Bardhaman.
- Damodar Valley project: Has an irrigation potential of 4,83,500 ha with ultimate irrigation potential of 5,10,110 ha. Moderates floods of 6.51 lac cusec to 2.5 lac cusecs in addition to providing water for irrigation, industrial, municipal and domestic requirements in West in the districts of Burdwan, Bankura & Hoogly. 30,000 ha of land in the upper valley is being irrigated, every year by lift irrigation with the water available from 16,000 (approx) check dams constructed by DVC.

- Kangsabati Reservoir Project: Has an irrigation potential of 3,48,477 ha. Covers the Districts of Bankura, Midnapore and Hooghly.
- Midnapore Canal: Irrigates 49,879 ha. Derives water from River Kangsabati and extends from Mohanpur to Uluberia on river Hoogli
- Teesta Barrage Project: The Phase I has started. By the end of Phase III, it will have 9.22 lakh ha of irrigation potential. Will cover 6 districts,namely, Cooch Bihar, Jalpaiguri Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, and Malda. Will also produce Hydropower for the state, in addition to providing water for agriculture, drinking water and industry.
- Subarnarekha Barrage Project: Envisages construction of a barrage across the Subarnarekha downstream of Chandil dam and Galudih barrage near Bhosraghat to irrigate 1,14,200 ha annually in the Medinipur district of West Bengal through a left bank canal and its distribution system covering a culturable command area of 96,860 ha.

Medium irrigation projects - completes and ongoing :

- Bankura: Berai Canal irrigation scheme (3.63 '000 ha)[10] and Suvankar Danra irrigation scheme (2. 43 '000 ha), Sali Diversion (2.27 '000 ha),
- Bardhaman: Jangal Mahal gravity irrigation (5.27 '000 ha)
- Birbhum: Hinglow irrigation scheme (12.38 '000 ha)
- Midnapore: Ranichak pump irrigation scheme (1.25 '000 ha)
- Purulia irigation schemes: Bandhu (2.43 '000ha), Kumari (3.63 '000ha), Saharajore (6.00 '000 ha), Turga (0.86 '000ha), Taragonia (1.07 '000ha), Dimu (0.47 '000ha), Barabhum (2.73 '000 ha), Ramchandrapur (2.56 '000 ha), Extension of Bandhu (0.53 '000 ha), Beko (1.59 '000 ha), Lipaniajore (1.59 '000 ha), Futiary (1.20 '000 ha), Paltoi (2.16 '000 ha), Kaira Beria (0.57 '000 ha), Golamarajore (1.00 '000 ha), Karrior (0.51 '000 ha), Tatko (2.48 '000 ha), Moutorejore (1.08 '000 ha), Parga (0.92 '000 ha)

Flood management: Is being carried out by the Irrigation Department through building of embankments to prevent saline ingress in the Sundarban areas through tidal waters and also at other parts of West Bengal to prevent flood waters from damaging agriculture areas such as in North Bengal along Teesta, Raidhak, Ganga, Jaldhak, Ajay rivers and renvation and remodeling of embankments along the Mayurakshi-Bhagirathi system and along Kangsabati river system. It excavates new drainage channels and enhances the drainage capacities existing channels of various river systems and also drainage of Kolkta. The Department aso regularly undertakes anti river erosion and anti sea erosion works.

Public Health and Engineering Departments: It is in charge of Rural Water supply, Urban water supply in non KMD municipalities, improvement of water quality standards vis a vis various types of pollutants infiltrating ground water that is used for drinking (arsenic, fluoride, and saline infiltration) and providing water for drinking during disasters.

[10] The irrigation potential of the medium irrigation projects are indicated in brackets

- As of March 2010, 36.66% of the rural population has been connected to piped drinking water, through 93732 direct connections. Other than this in the rural areas, the PHE department maintains 518210 number of tube wells for drinking water and about 94 public water schemes have been instituted by PHE with the help of Zila Parishads in 13 districts in West Bengal.

- As of March 2010, 85 municipalities and 88.7% of the non KMD urban population (i.e population of urban centres other than Kolkata) have been covered under municipal water supply schemes. Under the Accelerated Urban Water supply Programme, a scheme supported by the centre and the state together, about 25 municipalities have been targeted, of which 12 municipalities have been fully covered as of March 2009. At present, major augmentation have been taken up in Kulti, Jamuria, Siliguri and Raniganj municipalities.

- Steps have been taken to supply arsenic free potable drinking water in all the arsenic affected and surrounding villages under the “Bharat Nirman” programme by the year end 2011. The action plan envisages 349 Piped Water Supply Schemes to cover 3413 villages and 16.6 million population. beyond permissible limit.

- Presently, a programme of testing of all the tubewells for fluoride contamination in identified blocks is being carried out under Joint Plan of Action with UNICEF. A Master Plan for coverage of all the fluoride affected habitations is under preparation.

- The ground water in coastal area in southern part of the state is saline in nature. The ground water is supplied here from non saline aquifers and sometime by drawing water from non saline area through pipelines. Pond based water supply arrangement with proper treatment is also being encouraged. Membrane based desalination plant has also been installed in one area of North 24 Parganas District. PHE Department had taken up 262 rural piped water supply schemes in the saline belt of North 24 Parganas, South 24 Parganas, Purba Medinipur and Howrah Districts. 238 of them have been commissioned up to March 2009.

- Disaster recovery services are provided by PHE, by providing access to safe drinking water to the disaster affected population. It has distrubted safe water to population affected by floods in neighbouring state of Bihar in Purniya, and in North and south 24 Parganas to population affected by Cyclone Aila in 2009 and has restored tube wells and pump houses destroyed by Aila. Heavy landslides in Darjeeling due to heavy rains and strong winds during Aila, damaged the conduit systems of springs and Jhoras, which also have been restored by The PHE. *(All Information source for PHE is http://www.wbphed.gov.in)*

Water Investigation & Development Department: Due to rampant extraction of ground water to meet the needs of water intensive agriculture being practiced, the ground water has depleted in many areas in West Bengal (see Figure 5.5). Through the West Bengal Ground Water Resources Management, Control And Regulation Act (2005), the department is now in its initial stages of developing systems to manage, control and regulate indiscriminate extraction of groundwater in West Bengal, develop solutions towards controlling widespread contamination of water, devise methods to conserve the ground water resources by way of recharging, replenishing, recycling or reusing, in a co-ordinated manner, and encourage modern technologies and age-old practices of water harvesting and recharge to ensure ground water availability . It aims to continuously analyse, study and review the physical, chemical, bacteriological, and virological qualities of ground water and devise and implement pragmatic strategies. The Department operates through the State Water Investigation and Development Directorate (SWID) and District Level Authorities and the Corporation Level Authorities. The Water Resources Investigation & Development Department did the 4th Minor irrigation Census in 2006-2007in order to assess the actual number of minor irrigation structures and the irrigation potential created and utilized which in turn will also help for further planning in this sector. The final report is awaited.

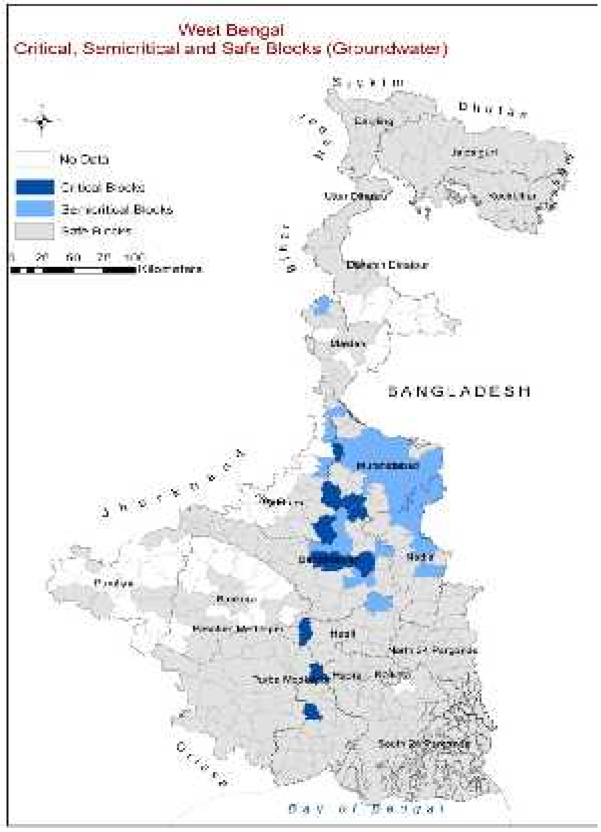


Figure 5.5: Critical, semi critical and safe ground water blocks of West Bengal

Source: WBPCB, 2009

Municipal Affairs Department, Govt. of West Bengal: It maintains Municipal Water Supply & Sanitation in Urban Areas. Some of the programmes, like the Employment Generation Programme (EGP) for the urban poor, it undertakes works on Water supply, Drainage, Canals and river banks, and Preservation of water bodies. Through the National Slum Development Programme (NSDP), it has created 4,51,905 meters of drinking water pipeline, 837588 meters of drains, 63462 meters of underground sewerage drains, and installed 6504 water taps, and dug 5403 and 212 number of shallow and deep tubewells (http://www.wbdma.gov.in/htm/MUNI_NSDP.htm). Under the JNNURM programme, it also aims at laying piplines for water supply and create drainage systems in urban slums of the

Mission cities of Kokata Metropoitan development Area (KMDA) and in Asansol through the provision of providing basic services to Urban poor. The non mission cities will also

West Bengal Pollution Control Board: Through the provisions of Water Act, 1974 (Prevention and Control of Pollution), the WBPCB regularly monitors water quality of rivers, such as Hooghly, Damodar, Barakar and Rupnarayan by analysing the physico-chemical, bacteriological and biological parameters. Under the Ganga Action Plan (GAP), the Board monitors the water quality of river Hooghly and under the Monitoring of Indian National Aquatic Resources (MINARS) programme, the Board monitors the water quality of the rivers Damodar, Barakar and Rupnarayan. The river water samples are collected every month from eight stations of river Hooghly, four stations of river Damodar, one station of river Barakar and one station of river Rupnarayan.

Impacts of Climate Change on Water Flows and Storage

The SWAT model has been run to obtain the projections of freshwater components i.e., blue water flow (water yield - quantified rain fall plus deep aquifer recharge), green water flow (actual evapotranspiration), and green water storage (soil water) at a sub basin level with daily weather data for all river basins of India for baseline (1961- 1990, IPCC SRES A1B) as well as GHG scenarios near term (2021 – 2050, IPCC SRES A1B) and long term (2071 – 2098, IPCC SRES A1B) (see Figure 5.6).

The blue water flow, is decreasing in West Bengal region from 1000 to greater than 5000 mm/yr in base line scenario to 800 to 1000 mm/year in the midcentury scenario, except for the North and south 24 Parganas where the blue water remains at >5000 mm/yr in the base line as well as mid century scenario, and in the Northern districts of Darjeeling and Cooch Behar where the blue water yield remains between 1000-5000 mm/year. By the end of the century (top panel, Figure 5.6).

Green water flow in West Bengal is increasing in the mid century as well as end of century scenario to > 1000 mm/yr in most parts of West Bengal. This has a direct relationship with increase in temperature leading to higher evapo transpiration rates.

There is a distinct decrease in green water storage in the South Western Part of West Bengal covering the districts of Purulia, Birbhum and East Medinipur Bengal in the mid century scenario with respect to the base line scenarios. The decrease is from 101-125 mm/yr in the base line scenario to 76 to 100 mm per year in the mid century.

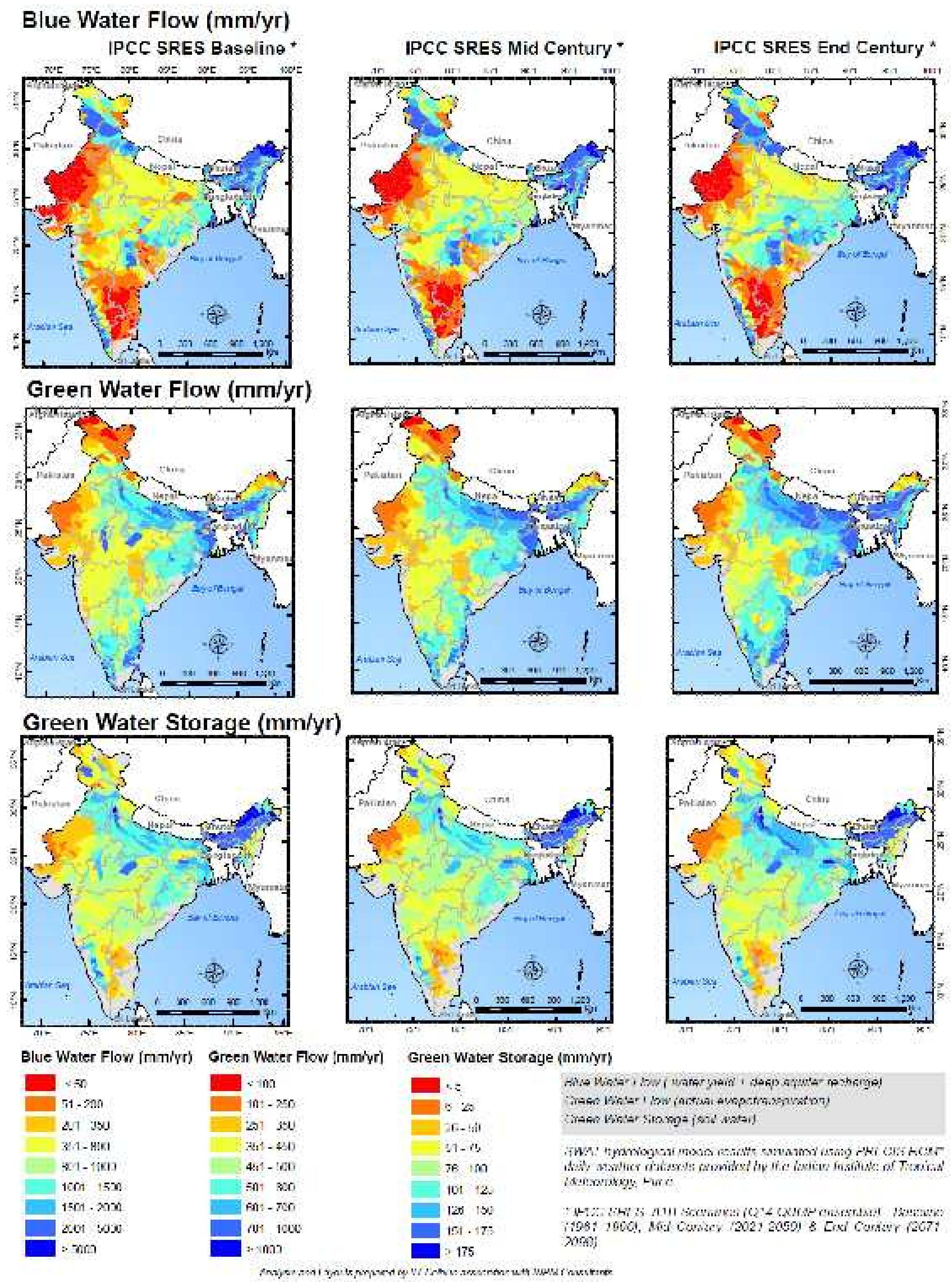


Figure 5.6: Blue water flow, Green water flow and and green water storage in Base line scenario, mid century scenario (2021-2050) and end of century scenario (2071-2098)

Strategies to address climate change impacts

Meeting water demand in the future, even for a business as usual scenario in the mid century will be difficult (refer to figure 5.2b). Climate change impacts will further enhance the demand, if the water availability varies across time and space as indicated in the earlier section. Therefore, an integrated approach to water management needs to be instituted to also take into account the constraints posed by climate change. Since there is a regional variation within West Bengal itself, in the observed changes in precipitation pattern, temperatures and also in the projected changes of precipitation, temperature, and yields of blue water, green water flow and storage, a region wise plan to address climate change concerns is appropriate. Following are some of the strategies that can be resorted to. These are based on brain storming within the departments, but cannot be limited to the same, as it is expected that with development in technology new and improved actions within each strategy may need to be taken up.

A. Hill region

Considering the impacts of climate change in terms of changes in rain fall, temperature, blue water flow, green water flow and green water storage, it is clear that the northern part of West Bengal is likely to remain water replete. During mid century, the post monsoon rain fall during October-November is likely to experience no change but will decrease in Jan-February period with respect to the base line (1970s). Increase in intensity of rain fall is also a possibility therefore retaining that water for ground water recharge will be a challenge. Even today, the water received as precipitation in the northern areas flows away due to the gradient towards the plains as well as to the neighbouring country Bangladesh. This water can be retained to a certain extent through recharging of ground water through water harvesting techniques. Therefore the strategies in the hill areas to ensure water security in the context of climate change can be as follows:

- Undertaking rain water harvesting along the hill slopes, especially in the recharge zones, to increase the percolation of rain water and thus result in the recharge of ground water. This can be achieved through digging up of staggered trenches with hedge row. Actions would also include identification of natural aquifers in the region.

- Initiate development of reservoirs intercepting River Jaldakha, Manas, Sankosh and other rivulets for transfer of water from Surplus Basin to Deficit Basin in this region. The feasibility of linking the rivers in this region can also be explored

- Construct check dams, wherever, feasible for the creation of water reservoirs for harnessing surface Water

- Increase water storage capacity by building household, community and village level reservoirs and repairing, renovating and restoring existing water bodies

- The Teesta Barrage Project is an ongoing project having a huge ultimate potential of 9.22 Lakh ha. Out of which, nearly 2 Lakh Ha of potential has been created. A detailed analysis need to be carried out to understand the whether the water flow in the 100 year period from now will remain as per the potential of the barrage perceived now, or it would reduce or increase. Accordingly, steps need to be taken to either augmnet water flow into the barrage or help excess water drain out without causing floods

Measures such as embankments and dams have not really helped the situation. National policy on floods advises to go for more non structural measures to combat floods, as floods also bring in the fertile soil on flood plains and flushes the rivers

B. The Old and New Alluvial Plains

The rain fall is projected to decrease in mid century period during the non monsoon months and experience no change or slight increase in the monsoon months (refer to figure 4.4), as a result, the overall blue water yield is expected to decrease in this region (Figure 5.5). However, the annual average green water flow or the evapo transpiration is projected to increase. The green water storage area is however shrinking, indicating that though the storage amounts in some areas of this region might still be adequate but, adequate ground water may not be avialble for extarction in the future. This means that in this region where ground water is overexploited for water for agricultural purposes is likely to face water stress.

Further this region may continue to face severe floods due to increase in intensity of rain fall, though the absolute volume of rain fall annually may decrease. Ground water recharge may be one of the greatest challenges here, as the water deficit from rainfall currently is met through ground water extraction. New and innovative ideas may have to be instituted to manage the water resources in this region. This region is also afflicted by arsenic infiltration into ground water, especially in ground water that are taken out of deep underground sources.

- Increase the reservoir storage potential of existing major irrigation projects in the region, such as that of Kangsaboti, Mayurakhi, and the reservoirs of the Damodar Valley project even the ones that are situated in Jharkhand. This can be done through removal of siltation of present reservoirs, blocking leakages in the reservoirs and lining of canal systems only on the sides to minimize percolation. The base need not be lined, as it helps also in the recharge of underground water.

- The waste water generated in the thermal power plants and other large industrial units may be recycled, so that partial demand of water of the plants is met through this process

- For limiting rampant extraction of ground water extraction the concept of region specific centralized ground water extraction systems may be created in areas which have been found suitable (connected to aquifers that have more than 80 m depth), based on sound scientific evaluation of the terrain, aquifers, rainfall receipt, and recharge zones. Facilitation should be provided for recharge of ground water in its recharge zone through rainwater infiltration. The water from this source will be only transferred when the demand is high, and is not met through the conventional major irrigation systems or in areas where surface water is not available.

- To avoid arsenic contamination from ground water and to augment the available water from major irrigation schemes, establishment more number of surface water based schemes, such as Lift Irrigation Schemes for irrigation and drinking water on location specific basis may be encouraged in this region.

- Apply treatments for removing arsenic and other heavy metal contamination from drining and irrigation water

- In addition rain water can be harvested by construction of water harvesting tanks and ponds, and expanding the capacity of present ponds which are under direct command of the farmers and can be utilized in the water stress period.

- Enhance artificial Recharge activities in over exploited ground water areas (critical Blocks) through recharge structures such as Percolation tanks, Check dams, Recharge wells, Recharge shafts/pits, and creation of subsurface dykes

- Undertake resuscitation of Derelict channel with provision of sluice gates for storing rain water

- For abatement of floods in this region, a rethink and hence revamping of the existing infrastructure and making new infrastructure that help water pass through and drain out may be needed. Also incorporation of early warning systems may need to be put in place, with installation of rain gauges at higher spatial resolution and installation of LIDARS for real time analysis, and 7 day forecasting, to the population. Also in near term excavation of derelict channels, blocked drainage and construction of new drainage might be taken up especially in cities.

C. The Red and Laterite Region

As per the climate change projections available in this document (Figure 4.4, and 4.5), the rain fall is likely to increase in the eastern parts of Purulia, during monsoon period in the middle of the century, but other parts of this region are likely to experience no change with respect to 1970s. There is however, a distinct decrease in rainfall in the non monsoon periods, with no change indicated for the eastern part of Purulia during Oct-Nov period. The net changes in annual blue water flow (Figure 5.5) also show a decrease in the mid century with respect to 1970s in this region. The green water storage, i.e the soil water is decreasing in the mid century with respect to 1970s (Figure 5.5, lower panel).

This region already suffers from recurrent droughts, and the ground water potential as it is not very high with respect to other regions of the state. Policies that augment the storage of surface run off need to be boosted here. Some of the adaptation strategies that can be instituted can be as follows:

- Undertake special afforestation programmes to increase the run off infiltration ratio through joint forest management practices in and around spring sheds and increase stream flow by creating recgharge structures along the hill slopes through which the streams flow.

- Undertake extensive rain water harvesting through dug up pits or directing rain water to the recharge zones to enhance ground water recharge, reduce sediment load, and rejuvinate moribund rivers.

- Create small reservoir schemes such as check dams, that intercept rivulets, Nalas, with canal system in this region

- Encourage surface water schemes, through rain water conservation in ponds/dighis as hard rocks in the area do not provide access to deep acquifers which are free from fluoride. This approach might be more fruitful in the long run as compared to cost intensive fluoride intensive technologies being propagated presently.

- Since the red and laterite area is a water deficit area, agriculture in this region will benefit from the construction of the proposed Subarnarekha barrage, which at the moment is not part of the Accelerated Irrigation programme of the Government of India.

- Undertake mitigation of fluoride and other heavy metal from water

D. Saline Coastal region

According to recent observations (2000-2009), this region is also experiencing lower rain fall than expected in the non monsoon months. The region faces the impacts of recurrent cyclones which breaches the embankment separating the area from the sea. It has problems of availing sweet water for drinking, agriculture, and other purposes, as the water is saline due to sea water incursion into the soil as well. Deep tubewells are being used to get sweet water from deep aquifers which are 300 m down. Also another problem faced by this region is the erosion of land by the sea.

However, as per the climate change projections for the middle of the century, this region is not likely to face water scarcity even in the mid century as far as the projections of rain fall in the monsoons and the annual blue water is concerned. Even the green water storage remains the same as in the baseline i.e 1970s. With climate change, the sea level is likely to rise further, causing larger area inland to be inundated. Also the intensity of the cyclones is likely to increase giving rise to stronger storm surges.

In view of the above the main strategies that need to be put in place to ensure water security of this region may be as follows:

- Enhance the activities of the Sundarban Development Board by creating more number of “Rain Water Harvesting Scheme with land Shaping”

- Reconstruct the Sundarbans embankment in vulnerable areas through public and private partnership to entrust the management of the embankment to public as well. Undertake stabilisation of embankment slope, and create drainage through the embankment to drain out high tide water.

- Construct sluices to prevent the intrusion of saline water in channels where it does not exist

- Desalination project of river water in coastal areas

E. Scientific assessments for better understanding of impacts of CC

- Institute an early warning system for floods by (a) by installing automatic weather stations including rain gauge at all 23 drainage basins and hydrographs at the coast line at high spatial resolution, (b) LIDARS at appropriate spacing for an overall coverage of the atmospheric parameters, (c) create capacities in the state to undertake real tie analysis and hence near and long term forecasting of extreme rain fall and onset of monsoon and (d) dissemination systems to make all farmers and the entire population aware of the impending event.

- Assess water demand by sector by factoring in Climate change for short, medium and long term time lines

- Monitor quality of water to understand the impacts of warming of the atmosphere and for providing remedies

- Identify vulnerable areas of ground water contamination by point sources of industrial, municipal solid waste landfills and agricultural pollutants and R&D on contamination mitigation

- Undertake mapping of water availability in time and space – in Minor surface water bodies, Aquifers, and Water use in conjunction with land use and land classification

F. additional policy related strategies

- Modernize the Irrigation system using Drip, Sprinklers systems.

- Pricing and Regulation: Lack of metering is an issue in West Bengal. Piped water usage for domestic and drinking water can be subjected to metering and thereby restricting unnecessary wastage of water can be avoided

- Undertake periodical census of minor irrigation projects to check sustainability and also to detect dis-functionalities and to implement remedial measures

- Variable Irrigation Water Tax on surface water use and ground water use might be levied, depending on the land holding size, to minimise use of ground water for irrigation and also to reduce wastage of the water obtained through surface resources. This may also encourage small and medium farmers to have their own water storage structure to irrigate their fields.

- Extend compulsory rain water harvesting regulation in individual houses in all towns in

See Table 1, in Annexure 1, for details of Adaptation Strategies, Actions, time lines and budgets.

6.0 Agriculture

Introduction

Agriculture is the primary occupation in the State of West Bengal. It is the main stay of 62.7 per cent of rural work force, and about 70 per cent of the rural population depends on agriculture for their livelihood. The state's six agro-climatic zones, namely **Hill zone, Terai zone, Old Alluvial and New Alluvial zones, Laterite zone and Saline Coastal zone** offer an extensive and diverse climate, soil, water availability through irrigation and rainfall, and biodiversity creating diversified cropping systems. The agriculture sector in West Bengal is characterized by the predominance of small and marginal farmers tilling more than 68% of the total cultivated area. Average per capita land holding in the state is less than 1 ha. Contribution of agriculture and allied sectors in State Domestic Product is 24.32% and of this crop sector contributes 20.3%. The growth rate of this sector, however, has plateaued over the years at about 2%.

Due to limitations in land available in the state for agriculture, the cropping intensity is one of the highest amongst all the states in India. It increased from 131% to 185% over last two and half decades putting tremendous pressure on soil and water resources. Despite these pressures, the state achieved an all time record in food grain production and ranked first in production of rice in the country in 2010. The rate of growth of production of rice is about 3% per annum. The state produces 28% of the total potato in the country and the rate of growth per annum is 12%. West Bengal has made a remarkable progress in oilseed production which increased from 0.24 million tons to 0.55 million tons in last decade. West Bengal also is No.1 in the production of jute and produces nearly 60% of the country's raw jute fibers. There is potential to grow scented rice, off-season vegetables and fruits as well. The spatial spread of major crops grown in West Bengal is shown in Figure 6.1 and the percentage production of crops in the various agro-climatic regions is shown in Figure 6.2.

The horticulture sector in West Bengal is wide ranging and produces considerable amounts of vegetables, fruits and nuts, spices, medicinal plants, aromatic plants, mushroom, etc., under different agro-climatic conditions. All the agro0climatic regions, particularly, the hills and terrain regions have possibility of multi-tier cropping systems which can enhance the returns per unit area of land and time, generating employment potential and providing food and nutritional security. The farmers are also producing non-traditional vegetables like baby corn, brussels sprout, gherkin and broccoli. Over the years, productivity of these horticulture products in West Bengal has increased considerably. In 2008-09, the state produced 2775.60 thousand tons of fruits and 12803.46 thousand tons of vegetables.

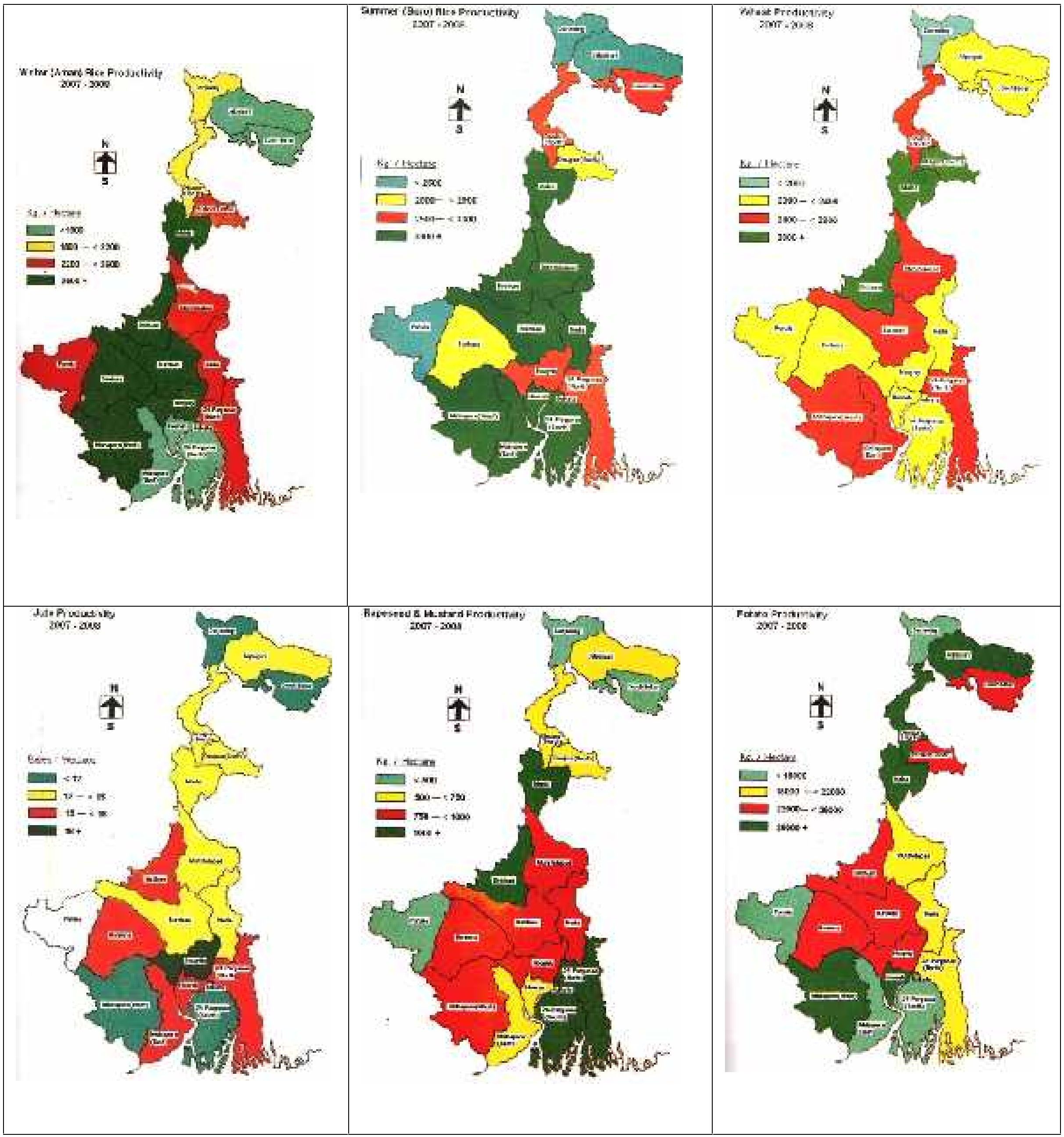
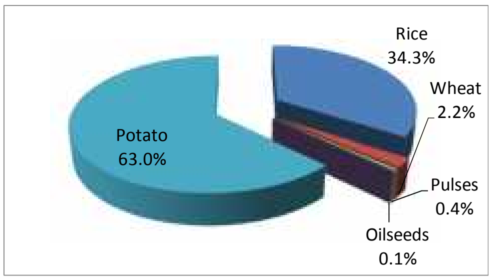
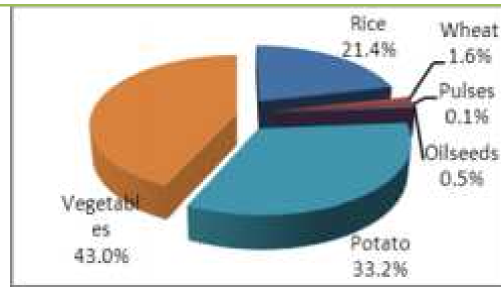


Figure 6.1: Spatial spread of major crops in West Bengal

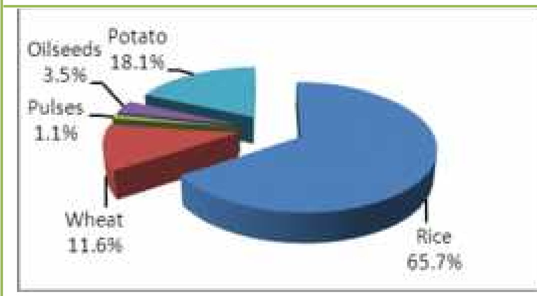
Source: Directorate of Agriculture, Government of West Bengal



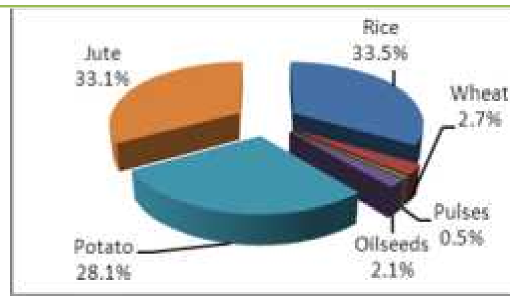
Hill Zone



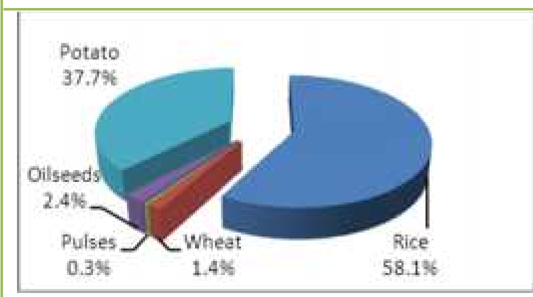
Terai zone



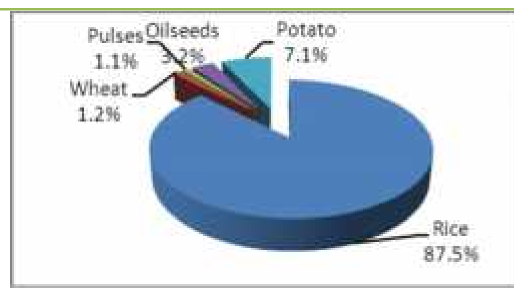
Old Alluvial Zone



New Alluvial Zone



Red and Laterite zone



Coastal Zone

Figure 6.2: Distribution of major food crops grown in different agro-climatic zones

Source: Background Paper, SAPCC working group on Agriculture, Directorate of Agriculture, West Bengal

The number of livestock population is large in the state, but the availability of livestock products is below the Indian Council of Medical Research (ICMR) norms. However, availability of animal products increased over the years. For example, milk production increased from 10.64 lakh tons 1976-77 to 41.95 lakh tons in 2008-09. During the same period the meat productions were 1.29 lakh tons and 5.27 lakh million tons and egg productions were 676 million and 3105, respectively. The corresponding internal requirements of the state for milk, meat and egg for 2007-08 as per ICMR norm had been 57.47 lakh tons, 9.58 lakh tons and 8747 million, respectively. In West Bengal, all livestock and poultry are indigenous and low-productive except Black Bengal Goat and Ghoongru pig. Augmentation of animal productivity is the most challenging constraint that the state needs to address. Availability of feed and

fodder is another serious constraint. There are certain limitations such as non-availability of land for fodder cultivation and acute shortage of availability of quality fodder seeds in the state are responsible for the shortfall of fodder production .

Next to rice, fish is the staple diet of Bengal's population and therefore, fish production is one of the key areas, where the state government puts a substantial part of its resources to maintain as well as enhance its productivity. West Bengal currently produces 30.18% of the total fish through inland fisheries in India - highest amongst all the states. In 2008-09, it produced 1294710 million tons of fish through inland fisheries (Figure 6.3). As regards marine fisheries, though West Bengal is not the top producer, but it produces 6.15% of the total marine fish production of the country, which was around 189290 million tons in 2008-09.

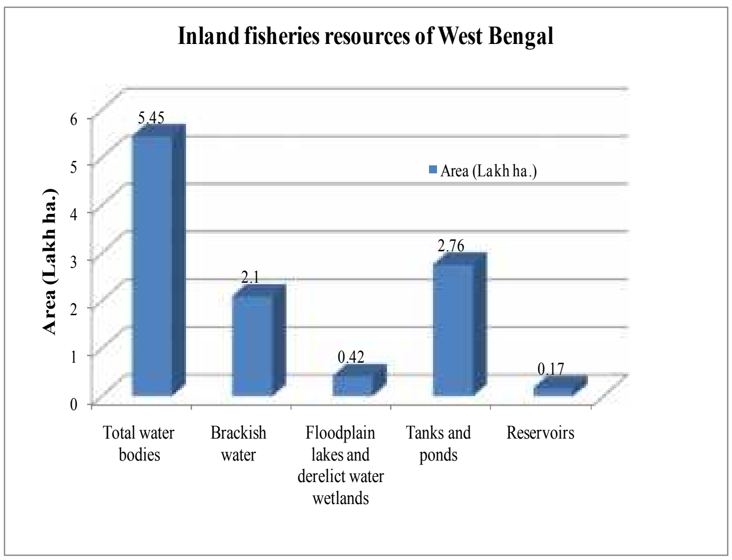


Figure 6.3. Inland fisheries resources in West Bengal

Source: Background paper on fisheries, M K Das, Central Inland Fisheries Research Institute, West Bengal

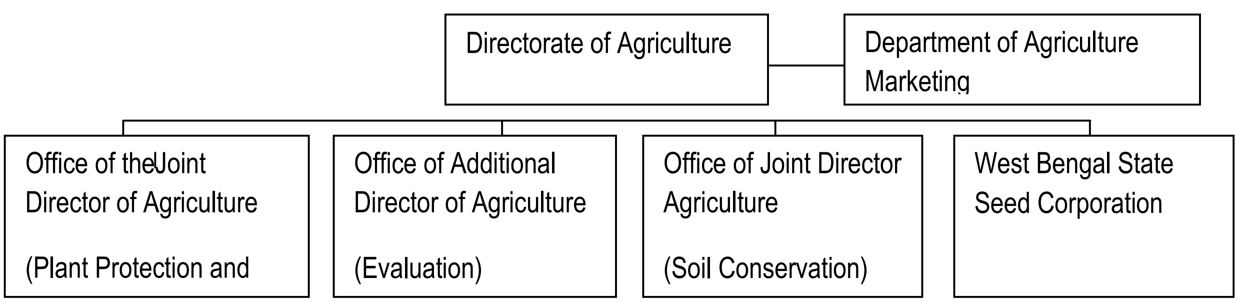
Delivery Institutions, Policies and Programmes in the agriculture Sector

Agriculture -Crop productivity: West Bengal is surplus in production of rice but there are deficits in the production of wheat and pulses. For increasing productivity, the state has adopted policies of using quality seeds, fertilizers, plant protection measures as well as improved package of practices such as crop diversification and distribution of waste land to the actual tillers through land reforms.

The requirement of food grains during 2006-07 was around 168.39 lakh tons and the production was 159.75 lakh tons. The deficit was mainly due to less production of wheat and pulses. Keeping this in mind various state plan and Centrally Sponsored Scheme have been operationalised during the eleven plan period. National Food Security Mission has been started across 12 districts of the State to boost up the production of wheat, pulses and rice. Apart from this hybrid rice seed production programme, the Integrated Scheme of Oilseed, Pulses, Oil palm and Maize (ISOPOM), development of cultivars of rice fortified with Zinc & iron, research on suitable pulse and oilseed varieties, potato tissue culture, short duration wheat varieties have been taken up. Also dryland/rainfed crop production programme and special area development programme are also in operation.

For meeting the food security of the state, many of the infrastructure important for agriculture such as the renovation of the Government Seed Farms, Commodity Research Stations and Meteorological observatories have been beefed up. Measures such as Soil & Water Conservation including Soil Survey & Testing, Natural resource management and construction of water harvesting structures, Integrated Pest Management measures, Training and skill development of farmers on modern agricultural technologies, Diversified cropping programme for dry and Laterite regions, two new schemes Development of Zonal Adaptive Research Station & Development of Commodity Research Stations of the State have also been taken up. Agriculture markets have been strengthened along with measures to cover crop failure through crop insurance for specific crop types.

The institutional set up through which the government implements its programmes and policies in the Agriculture sector is as follows.



Policies of the Agriculture Department

- Raising agricultural production and Productivity through wider adoption of appropriate eco-system-specific and cost effective technology.
- Bringing more area under high yielding variety and hybrids of crops.
- *Strengthening seed certification and seed testing functionaries and ensuring timely supply of certified seed.*
- Use of balanced dose of fertilisers and nutrients.
- Increasing production of pulses and oil seeds in non-traditional areas and non- conventional seasons.
- Encouraging small and marginal farmers including Scheduled Castes and Scheduled Tribes & women.
- Intensifying agricultural programme in the low productive and inaccessible areas - Coastal saline zone, Red and lateritic Zone, Tista Tera Alluvial Zone an Northern Hill Zone.
- Encouraging the farmers for mechanization through the use of agricultural implements and machines for timely farm operation, and reducing cost of cultivation.
- Maintaining soil health, use of bio-fertilizers, green manure and farm yard manure, balanced nutrition, consumptive use of irrigation water and conservation of surface water through Participatory Irrigation Management (PIM), need-based use of plant protection chemicals in Integrated Pest Management (IPM) concept and popularization of bio-pesticides and botanical pesticides.
- Extending soil testing facilities upto district level for proper use of fertilizer.
- Strengthening Agricultural Extension Service including Training & visit system to intensify linkage between research and extension workers.
- Managing crisis in the event of natural calamities and adequate budgetary allocation to mitigate the eventualities and adopting contingent planning.
- Creating employment opportunities to improve the socio-economic status of the farmers and removing sub-regional disparity.
- Exploiting surface water potential and reducing indiscriminate use of ground water, as far as practicable.
- Strengthening post-harvest technology for reducing loss and better marketability.
- Reducing Zonal and sub-regional imbalances.
- Promoting crop diversification.
- Promoting indigenous technology with ecology-specific productivity.
- Bringing in cultivable waste land and fallow land under cultivation.
- Promoting the concept of zero tillage/minimum tillage in vulnerable areas.
- Recycling water and arrangement for proper recharging of ground water.
- Promoting precision agriculture.
- Promoting low cost technology for increasing crop productivity.
- Increasing the cropping intensity from the existing 174% to 190% through scientific methods appropriate for the agro-climatic zones.

Horticulture: Initiatives in the Department of Food Processing Industries and Horticulture include distribution of hybrid vegetable seeds and fruit plants amongst small and marginal farmers in all the districts. It has supported schemes like setting up of shade nets and area expansion of the spices such as ginger and turmeric and beetle-vine. Subsidies are provided to farmers for buying hand sprayers, pump sets and mango harvesters. Twenty nurseries have been set up for the poor farmers in 3 districts - Dakshin Dinajpur, Uttar Dinajpur and Burdwan. Undertook digging of dug-wells in dry areas such as Purulia, Bankura, Birbhum and Paschim Medinipur districts for promoting horticulture. Impetus given to Mushroom Development Scheme at Chinsurah.

Policies of the Department of Food Processing Industries and Horticulture:

- To improve production quality and productivity of horticultural produce so as to increase the returns to farmers as well as make the products competitive in the export market.
- To encourage private entrepreneurship for processing of fruits, vegetables and other horticultural products.
- To encourage commercial horticulture and value addition to horticulture products.
- To promote food processing industries in the State.
- To develop infrastructure facilities required for commercialisation of horticulture.

The State Government in collaboration with APEDA has set up five Agri-Export Zones (AEZ) for pineapple in the districts of Jalpaiguri, Coochbehar, Darjeeling and Uttar Dinajpur; for litchee in Malda, Murshidabad, 24-Parganas (North and South); for potato in Burdwan, Howrah, Hooghly and Paschim Medinipur; for mango in Malda and Murshidabad; and for vegetables in North 24-Parganas, Nadia and Murshidabad.

There are 11 Horticultural Farms under the State Government where production of planting materials, demonstration trials and other research works are conducted. These farms are being modernized to train the farmers and entrepreneurs for adoption of modern technologies, pre- and post-harvest management including organic farming.

Most of the national schemes are operational in the state for enhancing horticulture produce in a sustainable manner. The National Horticulture Mission (NHM) covers fruits, vegetables, root and tuber crops, mushroom, spices, flowers, aromatic plants, cashew and cocoa. The Micro Irrigation scheme has brought about 206.28 hectares of land for horticulture production. The major districts adopting micro irrigation are Bankura, Burdwan, Paschim Medinipur and Uttar Dinajpur. The National Bamboo Mission (NBM) and National Mission on Bamboo Technology & Trade (NMBTT) are focussing on bamboo development, bamboo based handicrafts and industrial development for improving rural economy through poverty alleviation. The National Mission on Medicinal Plants, supports cultivation of medicinal plants, development of processing units, and marketing infrastructure. The Rashtriya Krishi Vikash Yojana promotes farm mechanization, production of seeds and quality planting materials, establishment of nurseries, and creation of Horticultural Training Centres and Capacity building of Farmers and Entrepreneurs.

Food quality testing laboratories have been set up across the state including in Department of Horticulture and Department of Agricultural Chemicals at B.C.K.V, Jadavpur University, Techno India, Salt Lake, and at U.B.K.V., Coochbeehar. More such laboratories need to be set up. Also the State Government is establishing food parks at Malda, Sankrail, Chakgaria (South 24-Parganas), Kandua, Shankarpur (Purba Medinipur), Sultanpur (South 24-Parganas), Kakdwip (South 24-Parganas), Haldia and Siliguri in order to provide common facilities such as power supply, water supply, quality control laboratory, effluent treatment plant, cold storage, ware house, etc. to the entrepreneurs for setting up food processing units.

The extent of activities undertaken by the Directorate of Cinchona & Other Medicinal Plants, West Bengal is from almost the foot hills to an altitude of 1800 m in the hilly terrain of Darjeeling district. It grows different species of Cinchona trees for Anti-Malarial drug Quinine. Also it undertakes cultivation of *Cephaelis ipecacuanha*, *Dioscorea composita*, large Cardamom, Rubber, Mulberry, Turmeric, *Taxus bacata*, Broom stick, Citronella, Vetiver, Lemongrass, *Artemisia annua*, Mandarin Orange, etc. were started. It also does research and cultivates of Cinchona, Ipecac, Mandarin Oranges and Bamboo.

The institutional arrangement through which the Department of Food Processing Industries and Horticulture operates is as follows:

- Department of Food Processing Industries & Horticulture
  - Directorate of FPI&H
  - Directorate of Cinchona and Other Medicinal Plants
  - West Bengal State Food Processing and Horticulture

Fisheries: The state has developed infra-structural facilities like construction of roads, bridges, culverts, rural electrification, market complex, food parks, processing centres, fishing harbours and fish landing centres, transport communication, tourism, strengthened extension mechanism by way of organizing awareness camps in remote areas (through funds from National Fisheries Development Board, NFDB), river ranching (through NFDB funds), protection and rearing of endangered species, research & development and so on.

Policies of the Department of Fisheries

- To bring all water bodies for fish culture by the fishermen and unemployed youth.
- Protection of wetlands from filling and conservation of aquatic animals.
- Protection of aqua bio-diversity and environment.
- Eco-friendly sustainable fish culture.
- Setting up of infrastructure both in inland and marine sector for the over all development of the sectors and the people within.
- To create/generate man days employment and socio-economic development of fishermen community.
- Promotion of organic aquaculture.
- Women empowerment.
- Promotion of micro credit through STC.
- Implementation of Marine and Inland Fishery Act.
- Issue of ID for fisher men

Also welfare measures for fishermen are being pursued with equal emphasis. In consideration of export potential, steps have been taken to organize women's cooperatives in greater number in different districts for breeding and rearing of ornamental fish under NCDC and FFDA programmes. 78 co-operative societies for culture of ornamental fisheries, with 3311 women members, have been registered up to 2010. In order to meet the increasing need of fish seeds it intends to expedite setting up of hatcheries and fish feed plants in different places of the State, which would lead to employment generation in the fisheries sector in greater number. At the close of the 11th five year plan, the state target of employment generation in this sector has been fixed at 150000 units.

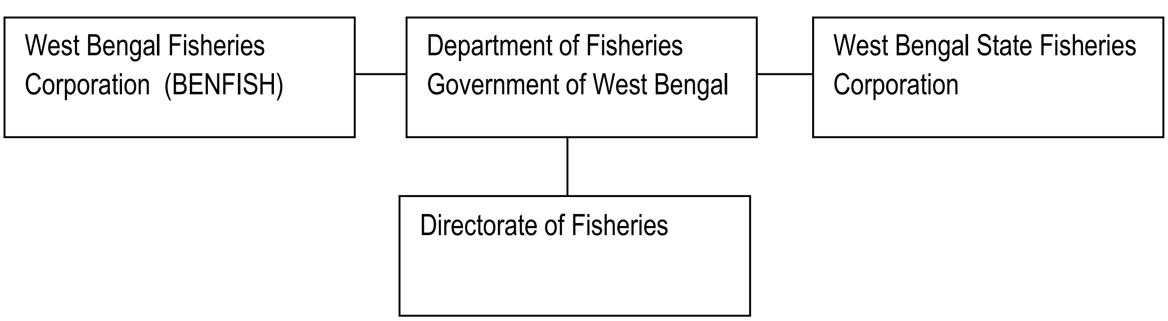
In the scheme of Rashtriya Krishi Vikash Yojana (RKVY), nets and boats to the riverine fishermen are being supplied, along with construction of a state of the art awareness centre and modernization of research activities. It also intends to undertake construction of Block level Fishery Offices, Brood stock management, Escalation of large water bodies, Research work, Training centres, GPS enabled vessel monitoring system and Solar lighting system.

The Department of Fisheries has taken up programmes to set up more number of hatcheries in the districts by introducing subsidy oriented schemes to attract the unemployed youths in the State to accept fisheries as one of the sustainable means of livelihood. Fish Farmers Development Agency have been set up for bringing more and more culturable water areas under the fold of pisciculture through FFDA, BFDA and Short-term Credit programmes.

Reclamation of Beels and Baors is being continued in the State under NCDC assistance. Further, the Fisheries Department has taken up a project for preparation of a comprehensive database and information networking in the fisheries sector by the use of remote sensing technology. For this purpose, very high resolution satellite imageries have been procured from NRSC to generate maps on the scale of 1:4000 in respect of the districts of Purba Medinipur, Paschim Medinipur, Bankura and Purulia for depiction of all the water bodies for an area of 5 cottah or more.

The State Government executes its policies and programmes through the Directorate of Fisheries, West Bengal and three organizations viz., The West Bengal State Fishermen's Co-operative Federation Ltd. (Benfish), State Fisheries Development Corporation (SFDC) and West Bengal Fisheries Corporation (WBFC). The Directorate is primarily responsible for execution of plan schemes. Other three organizations have their specific responsibilities. The Benfish executes schemes under NCDC assistance and WBFC is responsible primarily for execution of schemes under RIDF. The SFDC is primarily responsible for pisciculture in State owned farms.

The institutional set through which all policies and programmes of the government in the area of fisheries are executed is as follows.



Livestock and live stock products: To boost up fodder production in the State, the Government is regularly taking up a series of programmes / schemes for encouraging farmers to grow fodder in their own lands through various fodder development schemes; promoting cultivation of fodder in non-conventional areas like water-shed, waste lands, inter-spaces of various lands, orchard lands through plantation of different shade-tolerant fodder crops; developing pasture lands involving local bodies, reputed NGOs, self-help groups etc. It is supplying high yielding seedling and planting materials to the cattle owners with an emphasis on cross breed cattle owners in the form of mini kits; and organizing regular training programme on fodder production technology to the farmers / cattle owners / rural youths in all districts, etc.

Several programmes are also undertaken under RKVY such as Cattle and Buffalo Development including infrastructure development for sexing of semen, genetic upgradation of sheep and goat, Conversion of District Veterinary Hospital to Poly Clinic, Modernisation of Block/Additional Animal Health Centre, Establishment of BSL-III lab at IAH&VB campus, Kolkata, Development of Feed and Fodder, Heifer Rearing, Modernisation of Training Institute/Centre and Development of marketing facilities

Policies of the Department of Animal Resources:

- Lifting rural masses above poverty level through Animal Resources Developmental activities in each Gram Panchayat.
- Training of rural masses specially the women in scientific animal husbandry practice, arrangement of loan through financial agencies and supply the necessary inputs to them to undertake Animal Husbandry Schemes.
- Strengthening of Frozen Semen Technology in West Bengal and provide this facility up to G.P. level either through Govt. unit or through engagement of PRANI BANDHU –A self-employment venture.
- Establishing one veterinary Poly Clinic in each district.
- Establishing one District Composite Firm in each district.
- Establishing super specialist Disease Diagnostic Lab (RDDL) for referral cases of entire State and other Eastern, North Eastern states.
- Establishing Disease Investigation Network in entire State through establishment and strengthening of Diagnostic Laboratories.
- Establishing suitable research facilities in the field of Animal Bio-Technology and other areas veterinary science for the benefit of productive Livestock.
- Establishing Animal Disease and Management Information System throughout the entire State by computerized information system.
- Supplying of varieties of pasteurised liquid milk to consumers of different socio-economic status through Govt. Milk Depots and Milk agents in poly-packs.

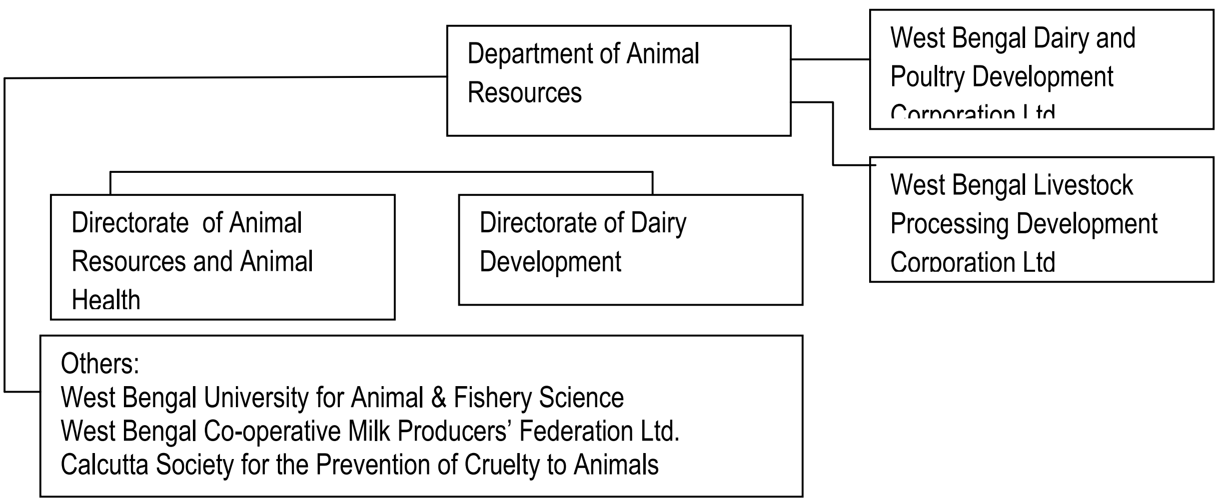
Under Rural Infrastructure Development Fund (RIDF), some important schemes that have been taken up include Infrastructure for Institution of Animal Resources at Haringhata Farm and Setting up Veterinary Polyclinic in Burdwan and Darjeeling.

The State Government has been implementing Alternative Animal Husbandry Programme for generation of gainful employment in the tribal dominated areas of Paschim Medinipur, Bankura and Purulia. Artificial Insemination (AI) isalso promoted. The Government has expanded the activities of West Bengal Co-operative Milk Producers' Federation Ltd. in the sphere of development of milk co-operatives and dairies in the State. In 2008-09 (up to

December, 2008), 322.58 thousand kg per day (TKPD) milk (including 60.77 TKPD milk from other sources) was procured from 3428 societies with 241469 members.

The West Bengal Livestock Development Corporation Ltd. distributed 20 lakh chicks in all the districts among Women Self-Help Groups in 2008-09. The Corporation has taken up the same programme during 2009-10. The Corporation has been entrusted with marketing of Government poultry meat like Turkey, Quail, Cockrail, Duck, Rabbit, etc. along with milk products of Government through various outlets of the Corporation.

The West Bengal Livestock Development Corporation Ltd. manufactures and distributes animal, poultry, fish and other livestock feed. During 2008-09, the production and sale of various livestock feed stood at 32588.934 MT and 32633.121 MT respectively. Two sylos of 500 MT capacity each has been installed at Kalyani Feed Milling Plant with central assistance under the Rashtriya Krishi Vikash Yojana to reap the advantage of bulk purchase during the harvesting time.



Concerns of the Agriculture Sector due to Climate Change

Agriculture crops

Though there is an inter-annual variability, the total precipitation across the state has a decreasing trend across all its agro-climatic zones, except for the hill region (refer to figure 3 a-f). According to the trends, change in precipitation in 2008 with respect to 1990 in the Terai zone, New Alluvial zone, Old Alluvial zone, Red and Laterite zone, and the Saline Coastal zone have all experienced a change of the order of -8.8%, -20.0%, -33.3%, -2.7%, and -2.1% respectively, with exception of the hill zone, where apparently though there is an inter annual variability, the trend is not declining.

Onset of monsoon is getting delayed and monsoon precipitation has become very erratic. In 2008-09, i.e. July 2008 to June 2009, a large part of the Gangetic West Bengal recorded heavy to very heavy rainfall in the 1st half. As a result of this downpour, accompanied by breaching of embankments of rivers traversing through these regions, vast areas of Paschim and Purba Medinipur came under the grip of unprecedented flood. Aman seedbeds, summer vegetables, jute, betel vine, flowers, etc. were damaged and the entire farming community had to incur irreparable loss. In 2009-10, however, there was shortage of rainfall, and a drought like situation was created, again leading to reduction in productivity of most of the crops.

The minimum temperatures are increasing leading to increase in winter temperatures that have begun to remain considerably above normal causing uncongenial situation for cultivation of most of the rabi crops. The rise in temperature during critical stages of wheat is leading to less production. The production of other winter crops like pulses and oil-seeds are also decreasing (Table 6.1). The area under total pulses decreased again this year to 184 thousand hectares from 200.9 thousand hectares during 2007-08. The production of total pulses decreased by about 10 and 18 per cent, respectively.

The observed increase in foggy and cloudy days in winter is further causing widespread damage of rabi crops, particularly potato (especially in 2008-09) due to increase in incidences of pest and disease. Its production was reduced to less than half of the production during 2007-08, with similar decrease in yield rate, though the area sown under potato was reduced by only 3.7 per cent (Table 6.1).

Increasingly the duration of high temperatures during summer is extending, and in spite of adequate rainfall, it is leading to reduced production of late-sown Boro paddy. Though the area under the crop was slightly more than the previous year, the yield was reduced by 14 per cent, resulting in 11.5 per cent reduction in production of Boro rice (4358 thousand tonnes during 2008-09) (Table 6.1).

Table 6.1: Trends of area under different crops and their productivity

Crop	Area ('000 ha)			Production ('000 t)		
	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
Aus	281.61	292.44	214.06	565.82	604.96	466.76
Aman	3926.54	4086.59	3986.33	9227.59	10074.26	9501.9
Boro	1511.59	1556.62	1429.7	4926.1	4358.01	4275.87
Rice	5719.75	5935.69	5630.09	14719.52	15037.24	14340.6
Wheat	352.57	306.98	315.88	917.28	764.52	846.65

Maize	77.17	90.77	97.71	244.37	343.43	385.21
Total Pulses	200.94	184.014	182.39	158.02	129.73	150.43
Total Oilseed	707.43	703.68	681.98	705.7	582.62	726.719
Jute	609.81	584.23	614.36	8216.03	7872.58	9324.96

Source: Economic Review GOWB, 2009-2010; Estimates of area and Production of Principal Crops in West Bengal 2008-2009, Directorate Agriculture, GOWB; Personal Communications, Directorate of Agriculture, GOWB, 2011.

Increase in intensity of extreme events such as cyclonic storms has been observed. On 25th May, 2009 a devastating cyclonic storm, Aila, caused havoc particularly in the coastal districts of the State. Vast areas in North and South 24-Parganas were inundated under saline water, causing large damage to agriculture of the Sundarbans.

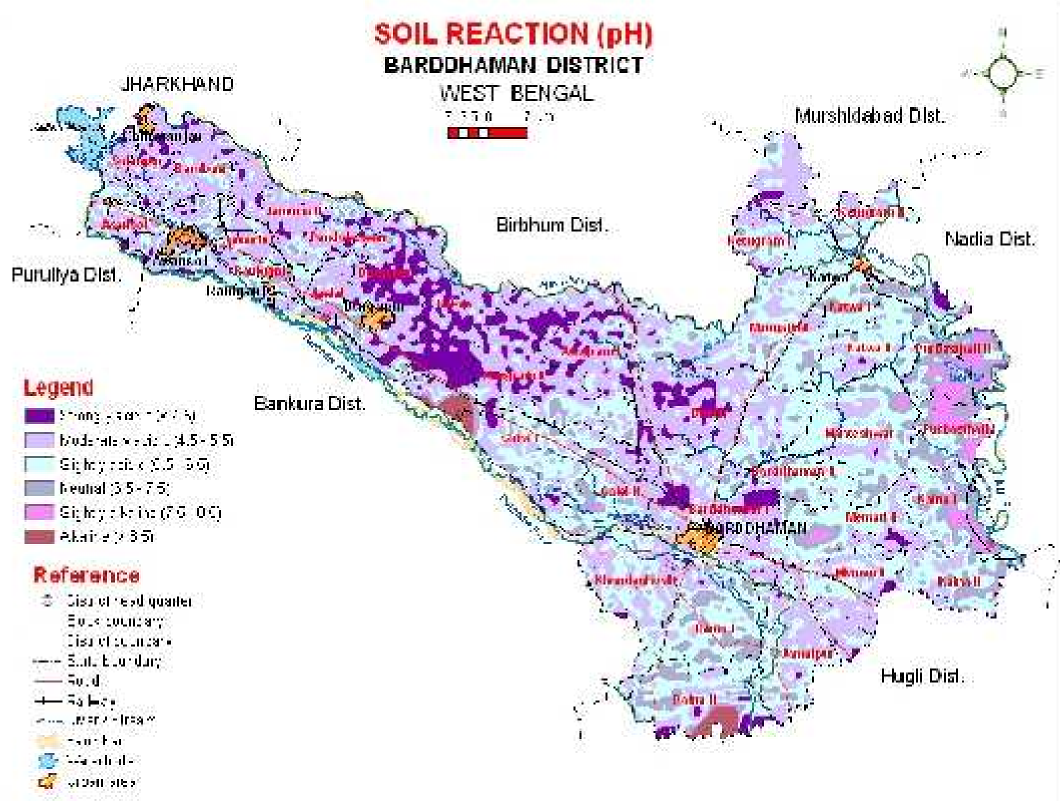
The soil characteristic is changing due to over exploitation. Massive external augmentation required to maintain soil health for optimum production. The soil health in Burdawan and districts representing the New Alluvial zone and the Red and Laterite agro climatic zone respectively are presented in the figures 6.4 and 6.5.

As air temperature is increasing, growth and multiplication of pests is taking place. Increase in length of extreme temperature will decrease soil moisture affecting soil microbes adversely.

Using the InfoCrop model driven by the climate scenario [derived from HadRM3 run on A1B IPCC socio economic scenario], it is projected that by 2030s, the potato production may decline by 4-16% in West Bengal (ICMR Network Project, Annual Report, 2009-2010). Simultaneously, there might be increase in soybean yields by 8-13%. Effect of climate change on groundnut is likely to be variable with yields varying between -5 and +7% as compared to current yields (ref: BCKV report, in Annual report 2008-09 of the Network Programme on Climate Change of ICAR).

A study carried out by BCKV using InfoCrop model (ICMR Network Project, Annual Report, 2009-2010) for the new Alluvial zone in West Bengal, indicates that if the temperature rises by 1°C, the yields of rice, mustard and wheat are likely to decrease. The decrease will be of the order of 830 kg/ha for kharif rice, 450 kg/ha for mustard and 640 kg/ ha for wheat.

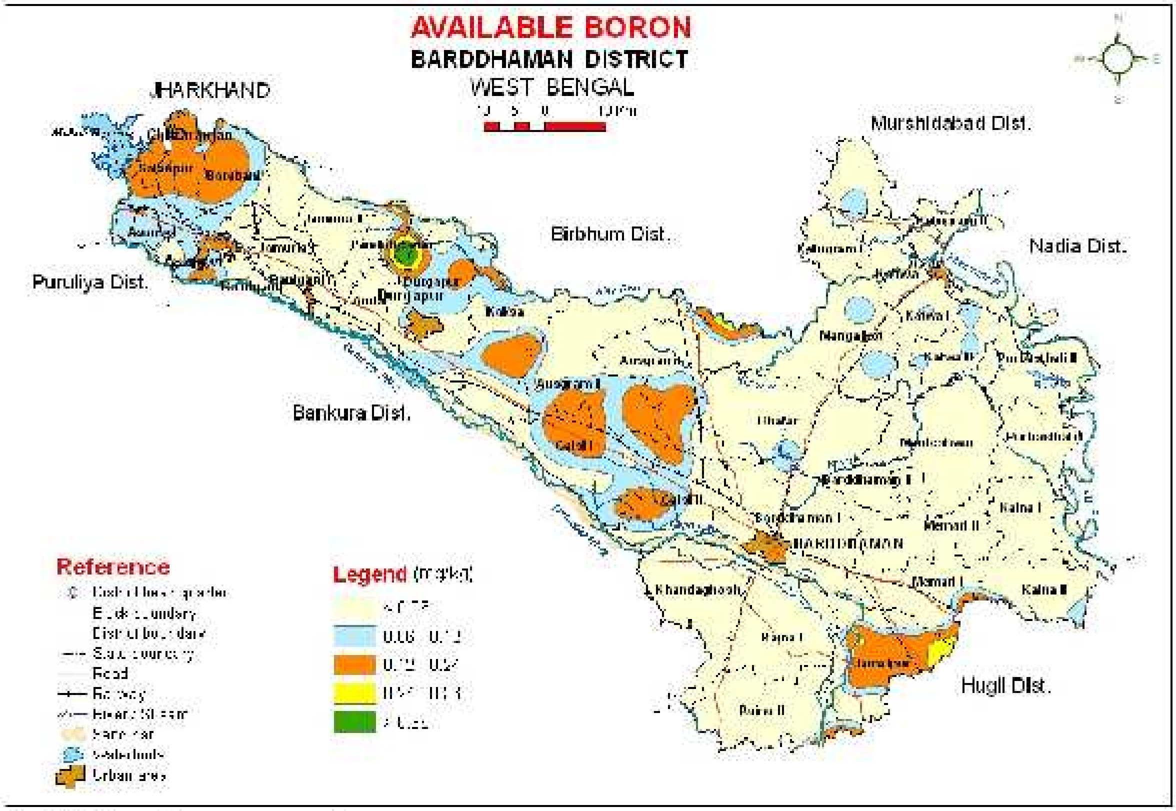
The productivity of potato in the entire Indo-Gangetic plain, of which West Bengal is a part, is likely to decrease by 2 to 19% and 9 to 55 % in the year 2020 and 2050, respectively since, the winters are already milder and further rise in winter temperatures would adversely affect the productivity (H.P. Singh, *http://www.niam.res.in/pdfs/DDG_Hort_lecture.pdf, accessed on 4th April, 2011).*



Soil reaction	Area (km²)	% Area
Strongly acidic	588.7	8.4
Moderately acidic (pH 4.5 to 5.5)	2661	37.9
Slightly acidic (pH 5.5 to 6.5)	2493.1	35.5
Neutral (pH 6.5 to 7.5)	814.9	11.6
Slightly alkaline (pH 7.5-8.5)	175.6	2.5
Alkaline (pH >8.5)	65.4	0.9
Miscellaneous	225.3	3.2
Total	7024	100

Figure 6. 4a: Soil reaction pH map of Burdwan District

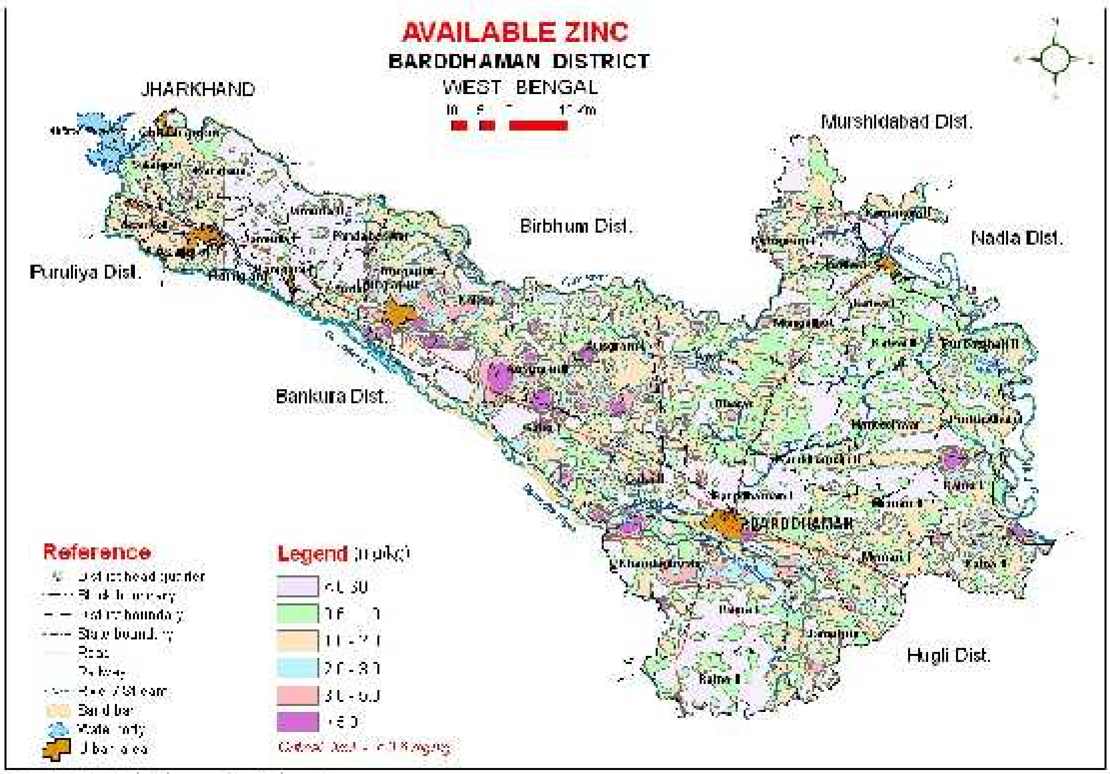
Source: Fertility Mapping Initiatives in West Bengal & their Significance in Reorienting Plant Nutrient Management, a project carried out by NBSSLUP in collaboration with Department of Agriculture, Govt. of West Bengal



Available boron (mg kg-1)	Area Km2	% Area	Rating
<0.06	5162.1	73.5	Deficient
0.06-0.12	908.2	12.9	
0.12-0.24	684	9.7	
0.24 - 0.36	32.6	0.5	Sufficient
> 0.36	11.8	0.2	
Miscellaneous	225.3	3.2	
Total	7024	100	

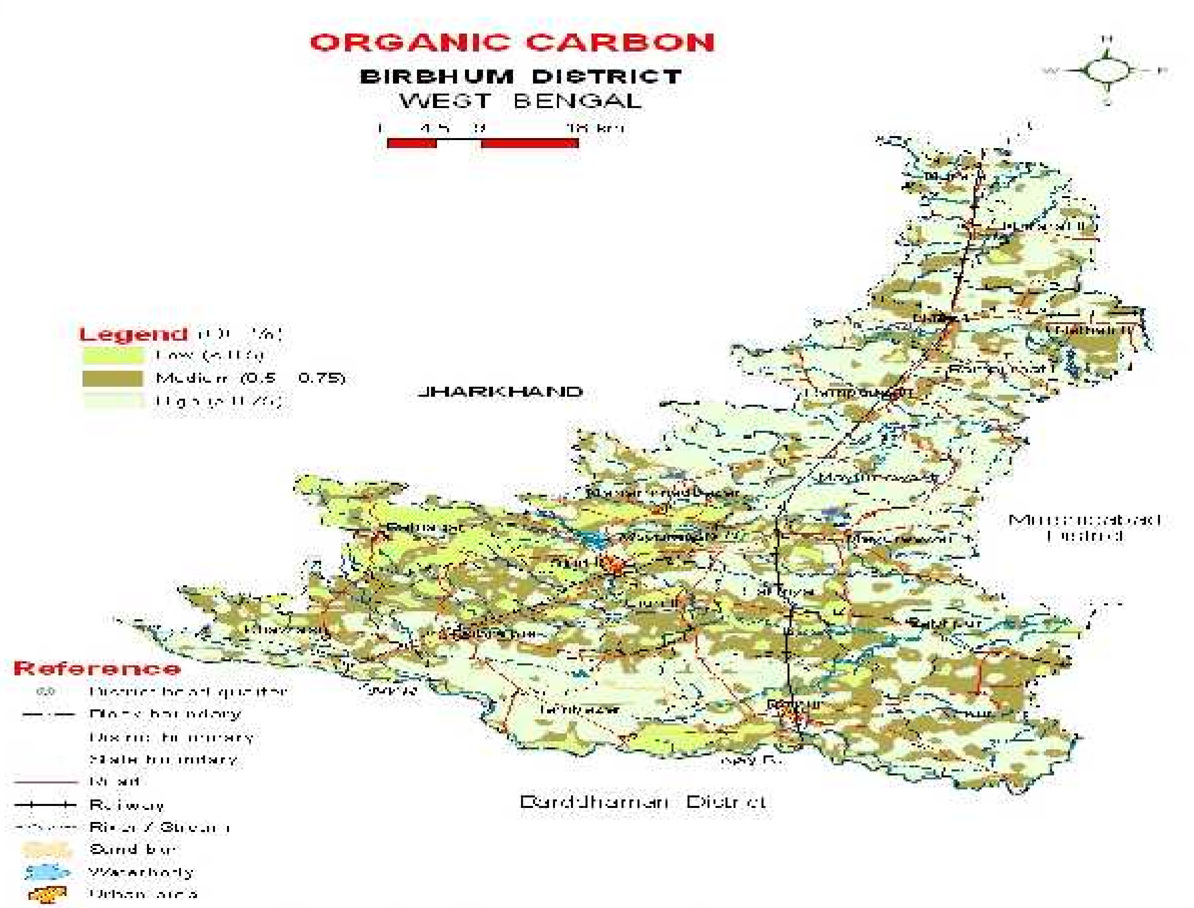
Figure 6.4b: Spatial distribution of Boron in Burdwan

Source: Fertility Mapping Initiatives in West Bengal & their Significance in Reorienting Plant Nutrient Management, a project carried out by NBSSLUP in collaboration with Department of Agriculture, Govt. of West Bengal



Available zinc (mg kg-1)	Area (km2)	% Area	Rating
<0.6	2298.9	32.7	Deficient
0.6-1.0	1896.2	27	Sufficient
1.0-2.0	1780.9	25.4	
2.0-3.0	480.4	6.8	
3.0-5.0	252.3	3.6	
>5.0	90	1.3	
Miscellaneous	225.3	3.2	
Total	7024	100	

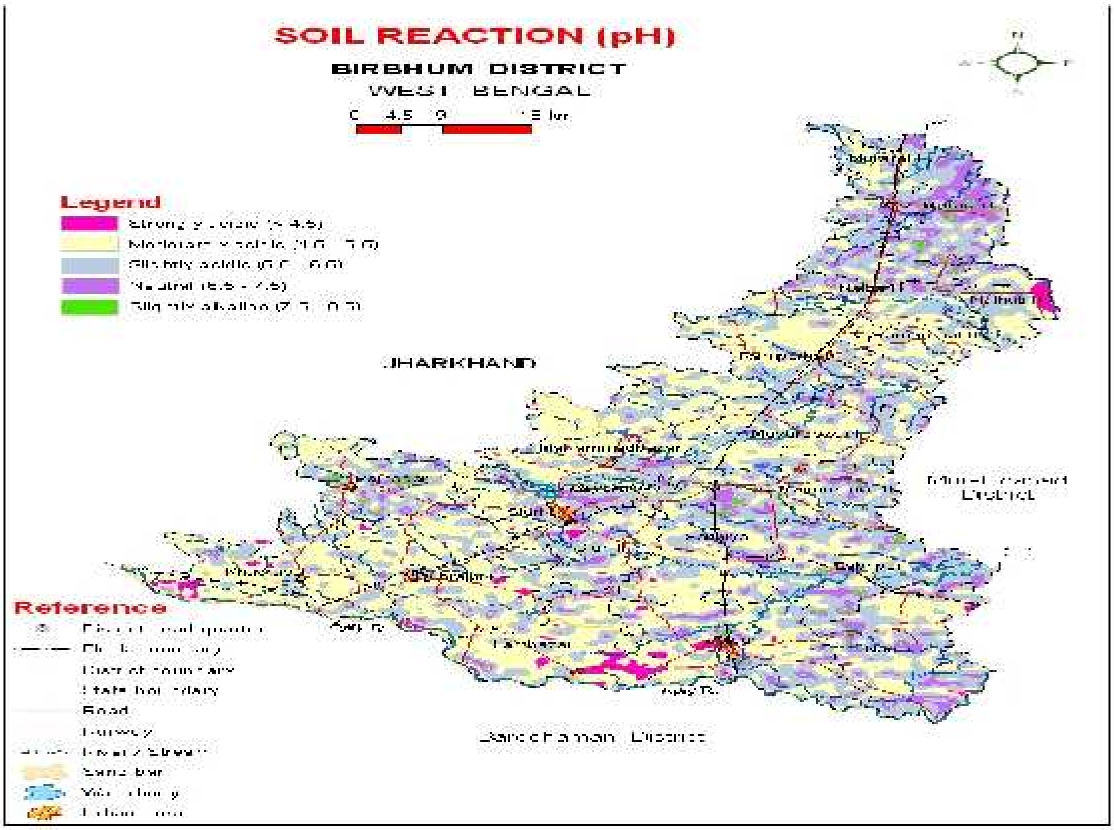
Figure 6.4c: Spatial Distribution of zinc in Burdwan
Source: Fertility Mapping Initiatives in West Bengal & their Significance in Reorienting Plant Nutrient Management, a project carried out by NBSSLUP in collaboration with Department of Agriculture, Govt. of West Bengal



Organic carbon (%)	Area (km²)	% Area
Low (< 0.50 %)	522.7	11.5
Medium (0.50-0.75 %)	1546.2	34
High (> 0.75 %)	2358.2	51.9
Miscellaneous	117.9	2.6
Total	4545	100

Figure 6. 5a: Organic C status in soils of Birbhum district (Red and Laterite Zone)

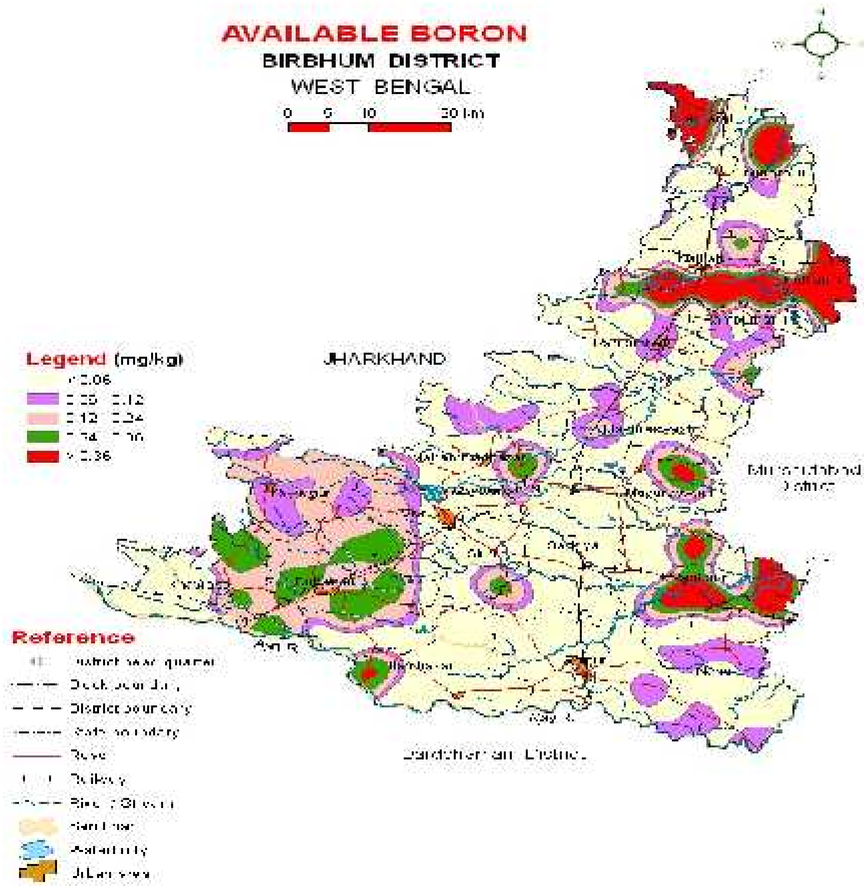
Source: Fertility Mapping Initiatives in West Bengal & their Significance in Reorienting Plant Nutrient Management, a project carried out by NBSSLUP in collaboration with Department of Agriculture, Govt. of West Bengal



Soil reaction classes	Area (km²)	% Area
Strongly acidic (pH <4.5)	98.7	2.2
Moderately acidic (pH 4.5-	2202	48.4
Slightly acidic (pH 5.5-6.5)	1648.7	36.3
Neutral (pH 6.5-7.5)	437.1	9.6
Slightly alkaline (pH 7.5-8.5)	40.6	0.9
Miscellaneous	117.9	2.6
Total	4545	100

Figure 6.5 b: Soil reaction in Birbhum district

Source: Fertility Mapping Initiatives in West Bengal & their Significance in Reorienting Plant Nutrient Management, a project carried out by NBSSLUP in collaboration with Department of Agriculture, Govt. of West Bengal



Available boron (mg kg^{-1})	Area (km^2)	% Area	Rating
<0.06	2596.4	57.1	
0.06-0.12	573.6	12.6	Deficient
0.12-0.24	647.4	14.3	
0.24 - 0.36	328	7.2	
> 0.36	281.7	6.2	Sufficient
Miscellaneous	117.9	2.6	
Total	4545	100	

Figure 6.5c: Spatial distribution of boron in Birbhum district
Source: Fertility Mapping Initiatives in West Bengal & their Significance in Reorienting Plant Nutrient Management, a project carried out by NBSSLUP in collaboration with Department of Agriculture, Govt. of West Bengal

Experiments conducted in field facilities such as Free Atmospheric CO2 Enrichment (FACE) facility, Open Top Chambers (OTCs) indicate that elevated CO2 level (560 ppm) leads to enhanced grain yield of rice, groundnut and wheat substantially at all nitrogen levels. Groundnut showed greater thermal sensitivity during post flowering growth phase than during pre-flowering growth phase. At elevated CO2 condition protein content in rice grains decreases. Reduction in protein content is upto 21.4% corresponding to a high N treatment (ref: IARI report, in Annual report 2009-10 of the Network Programme on Climate Change of ICAR).

Box 1: CO_2 enrichment mechanisms and likely impacts

Physiological response of elevated levels of CO2 varies between species, and in particular, two different pathways of photosynthesis effective in C3 and C4 plants (Gornal et al., 2010; Philosophical Transactions of the Royal Society, http://rstb.royalsocietypublishing.org). The difference lies in whether ribulose-1,5-bisphosphate carboxylase–oxygenase (RuBisCO) within the plant cells is saturated by CO2 or not. In C3 plants, RuBisCO is not CO2-saturated in present day atmospheric conditions, so rising CO2 concentrations increase net uptake of carbon and thus growth. The RuBisCO enzyme is highly conserved in plants and as such it is thought that the response of all C3 crops including wheat and soya beans will be comparable. Theoretical estimates suggest that increasing atmospheric CO2 concentrations to 550 ppm, could increase photosynthesis in such C3 crops by nearly 40% (Long et al. 2004). The physiology of C4 crops, such as maize, millet, sorghum and sugarcane is different. In these plants CO2 is concentrated to three to six times atmospheric concentrations and thus RuBisCO is already saturated (von Caemmerer & Furbank 2003). Thus, rising CO2 concentrations confer no additional physiological benefits. These crops may, however, become more water-use efficient at elevated CO2 concentrations as stomata do not need to stay open as long for the plant to receive the

Studies carried out by the Indian National Centre of Ocean information (INCOIS), using Satellite (ARGOS, a satellite-aided, global ocean monitoring system using buoys; GRACE, the twin satellites of NASA and Jason 2, a US-French satellite) and tide gauge data have found that the sea level in the Indian Ocean has risen by about 9 mm between 2004 and 2008, suggesting an annual rise of 2.25 mm. Global average sea level rose 1.8 mm per year at an average over 1961 to 2003. The highest level of rise has been noticed in West Bengal's Hooghly area, though Sea level rise is not the single factor for this higher level of rise at this location, it has global and local reasons. In areas like the Sunderbans, which faces a serious threat of inundation, sea level rise has a direct link to saline water intrusion in the coastal region, impacting agricultural practices.

Specific agro-climatic zone wise concerns are listed in Table 6. 2.

Table 6.2: Region specific key concerns due to changing climate in West Bengal*

Agro Climatic zones	Concerns
Hill Zone	○ Decline in size and quality of citrus such as mandarin orange due to rising minimum temperature during flowering of citrus trees. ○ Increase in runoff from enhanced intensity of rainfall leading to erosion and landslides. ○ Reduced productivity of Darjeeling tea due to increase in extended drought periods. In 2010, due to the prevailing

	drought and ageing of the tea trees (80 years) the productivity was the lowest in many years at 7.74 million kg as against the highest of 14 million kg in 1991 in the last two decades (*http://www.thehindu.com/sci-tech/agriculture/article1063434.ece, Kolkata Jan 7, 2011; accessed on 4th April 2011)* ○ Increase in winter temperature effecting potato and wheat. ○ Degradation of seed quality.
Terai Zone	○ Long winter periods conducive to wheat production in this region, but increase in winter temperatures reducing wheat yields. ○ Degradation of quality seeds. ○ Nutrient loss by enhanced leaching. ○ Long span of winter is an advantageous which can be exploited.
Old Alluvial Zone	○ Drying of natural water bodies due to extensive use of water for irrigation as the surface run off reduces ○ Excessive underground water extraction as demand exceeds availability which is over and above the receipt of rainfall, and available surface runoff ○ Rice productivity at stake due to water stress in future ○ Wheat productivity has decreased due to shorter winters ○ Temperatures in excess of 45-46 oC in summers is impacting productivity of oilseeds and pulses ○ Also excess temperatures affecting livestock productivity ○ Increase in pests and disease due to increase in foggy days affecting pulses ○ Degradation of quality seeds
New Alluvial Zone	○ Reduced availability of water has reduced the production on boro rice ○ Jute also requires intermittent irrigation, reduced amount of water availability may affect jute production ○ As jute crop requires humid climate with temperature fluctuating between 24 and 38 oC, any increase in temperature may effect jute productivity. ○ Further, as new grey alluvial soil of good depth receiving silt from annual floods is most suitable for jute growth, any increase in rainfall intensity in this region, is likely to remove the alluvial silt deposition, affecting jute productivity. ○ Degradation of quality seeds. ○ Decreasing potato yield with increasing winter temperature.
Red and Laterite Zone	○ Rainfall inherently scanty in this zone as compared to other agro climatic zones in West Bengal and is reducing further. In 2009 the rain fall was only 700 mm. ○ Also temperature, both maximum and minimum, are rising. ○ Agriculture mainly rain fed, only 27% of the land area is irrigated.

Saline Coastal zone	o Soil is poor in nutrient content and likely to become drier.. o Degradation of quality seeds. o Intrusion of saline water into the agricultural land resulting in loss of yields and greater risk to the farmer. After Aila, enhanced salinity in soil was tested upto 40 km from Kolkata. o Natural salinity of the soil is increasing due to recurrent intrusion of sea water, resulting in loss of agricultural land and making people migrate. o Longer span of summer increased insect and pest attacks on crops. o The delayed winter has hampered the cultivation of winter crops. o The intrusion of saline water causes severe stress on availability of drinking water. o Increasing humidity leads to incremental phenomenon of vector borne diseases. o Degradation of quality seeds.

** based on discussions with experts and their perceptions (BCKV, Department of Agriculture, Govt. of West Bengal)*

Fisheries

In the context of climate change, the primary challenge to the fisheries and aquaculture sector is to ensure food supply, enhance nutritional security, improve livelihood and economic output, and ensure ecosystem safety. Some of the impacts on inland fisheries can be as follows:

Seed availability: It has been observed that with increase in temperature there is a decrease in fish spawning and hence decrease in fish seed availability (Figure 6.6)

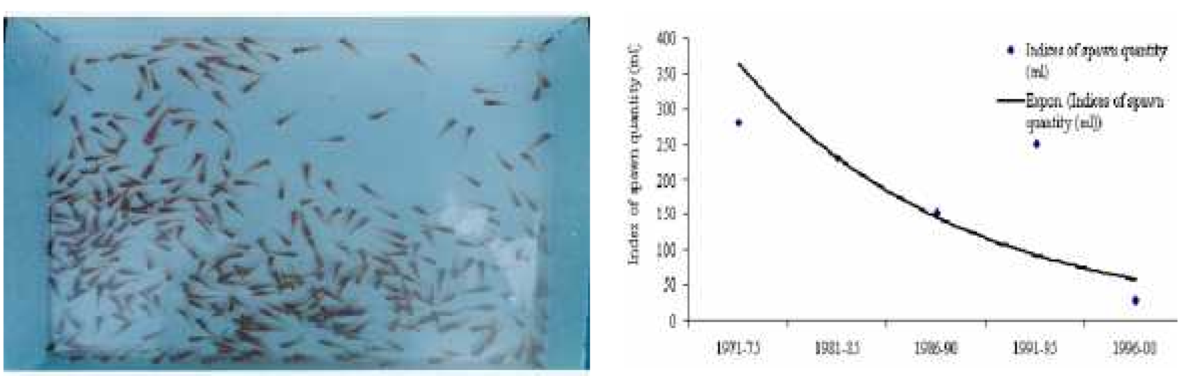


Figure 6.6: Decreasing fish spawn as temperature is increasing over the years
Source: Das et al., 2009, Central Inland Fisheries Research Institute, West Bengal

Growth of Fish: Temperature changes will have an impact on the suitability of species for a given location. In temperate areas increasing temperatures could bring the advantages of faster growth rates and longer growing seasons. Similarly for the Indian Major Carps the growth rate increases upto 33ºC but from 34ºC and above feeding is reduced and growth diminishes. This simple growth model provides a reliable projection of growth (SGR %) with unit rise of temperature within the range of 29º to 34ºC. Assuming these growth rates are constant, it would take average 77 days for a fish to double its weight at 30ºC to 33ºC and 35ºC, but at 34 ºC it would take only 35-36 days.

Enhanced breeding period of fish : Elevated temperature range (0.37ºC–0.67ºC) and alteration in the pattern of monsoon proved a major factor for shifting the breeding period of Indian major carps from June to March in fish hatcheries of West Bengal. Investigations conducted indicate an extended breeding period of Indian major carps by 40-60 days, with breeding season extending from 110-120 days (Pre1980-85) to 160-165 days (2000-2009) at present in fifty fish seed hatcheries in four districts of West Bengal, India viz. North 24 Parganas, Bankura, Burdwan & Hooghly. This has provided opportunities to the farmers to avail of the extended breeding period in producing valuable fish seed and supplement their income.

Geographical shift of fishes: A perceptible shift was observed in geographic distribution of the warm water fish species, *Glossogobius giuris, Puntius ticto, Xenentodon cancila* and *Mystus vittatus* towards the colder stretch of the river Ganga up to Haridwar with an enhancement of annual mean minimum water temperature of 1.5ºC in the Haridwar stretch during the period 1970-86 to 1987-2009. This stretch has become a congenial habitat for these warm water fishes of the middle stretch of the river. As a result fishers would have an enhanced yield and diversity in their fish catch from the stretch.

Drought condition prevailing in West Bengal during 2009 had impacted fisheries. District of North 24 Parganas rainfall was deficient by 29%, Bankura by 27%, Burdwan by 23% and Hooghly by 34% in the fish breeding months of March to September.

92% of the fish seed hatcheries have been affected by the deficit rainfall and increasing trend of temperature in the state. That results indicate about 61% and 73% loss of fish seed in North 24 Parganas and Bankura, respectively during 2009 compared to the previous four years.

The cyclone Aila affected loss to fishing equipments and aquaculture enterprises. Freshwater fishes in ponds were rendered ineffective due to salinity rise.

The vulnerability index for the fisheries sector of West Bengal indicates that fisheries activity is more susceptible to climate change (Table 3). Studies on inland fisheries (Central Inland Fisheries Research Institute report, ICAR- NPCC Annual Report 2009-10) indicated that drought in West Bengal during 2009 affected 92% of the fish seed hatcheries due to deficit rainfall and high temperature in the state. Freshwater ponds became unusable due to salinity rise because of cyclone.

For the fisheries and aquaculture sector, climate change notwithstanding, there are several issues to be addressed. Strategies to promote sustainability and improve the supplies should be in place before the threat of climate change assumes greater proportion. In the fisheries sector proper adaptive measures needs to be taken to combat climate change.

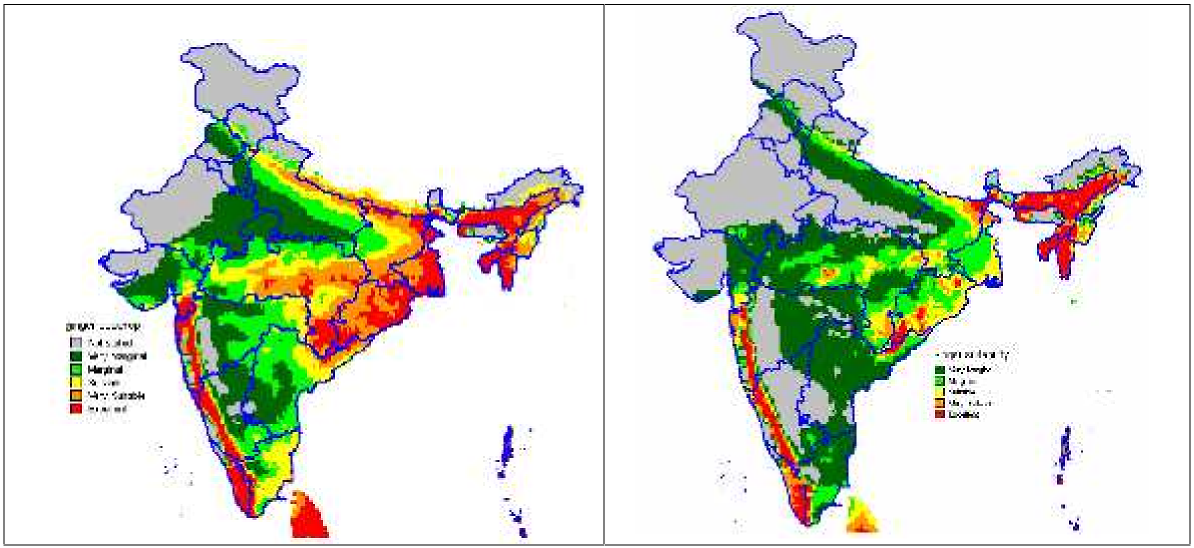
Table 6. 3: Vulnerability of fisheries in various districts of West Bengal

Districts	Vulnerability Score	Discussion /Explanations
24 Paraganas (S)	0.615	Fisheries activity in this coastal district of West Bengal is more exposed (0.17) of climatic events and adaptive capacity (0.27) is less in terms of limited opportunities for occupational diversification.
Murshidabad	0.552	For this district sensitivity (0.13) indicators are less vulnerable to climate change, though exposure (0.20) of climate change is very high and resilience (0.22) is too poor.
24 Paraganas (N)	0.549	In this district three components of vulnerability are at high level. The adaptive capacity (0.21) to climate change is very less than other two components and contributes more to overall index.
Nadia	0.527	Adaptive capacity (0.12) is less vulnerable i.e. very strong to climate change. But other two components sensitivity and exposure are at high level of vulnerability.
East Midnapore	0.5172	The adaptive capacity (0.15) is strong, but other two components in this coastal district are at high level.
North Dinajpur	0.5170	In the district of North Dinajpur, climatic variations and variation in production due to soil quality, tern to more vulnerable.
South Dinajpur	0.315	In this district, three components are at very low level in terms of less variation in fish production, climatic events such as rainfall, temperature, flood etc. and occupational options as measure of strong adaptive capacity.

Source: CIFRI, Annual Report ICAR-NPCC, 2009-10.

Horticulture Crops

Horticulture produces are being affected through multiple pathways due to the changing climate (*http://www.niam.res.in/pdfs/DDG_Hort_lecture.pdf, accessed on 4th April, 2011*). Horticulture in West Bengal constituting of fruits, nuts, medicinal plants, aromatic plants, flowers, ginger, saffron, and vegetables with tremendous economic value are likely to experience huge losses due to further changes in climate unless adaptive steps are taken now. As an example, it can be seen in Figure 7 that the ginger suitability sites are likely to shrink in West Bengal, when temperature increases by 1.5 to 2.0^{o} C. In fact the ginger production suitability becomes marginal in parts of new alluvial zone and in red and Laterite zones, only the best regions available for production get restricted to the hilly zone and the red and Laterite zone. .



(a) (b)

Figure 6.7: (a) Ginger site suitability map for India with current climate, (b) Ginger site suitability map for India with when temperature is likely to increase by 1.5 to 2°C.
Source: http://www.niam.res.in/pdfs/DDG_Hort_lecture.pdf, accessed on 4th April, 2011

Some of the likely impacts of climate change on horticulture include:

A rise in a temperature of above 1°C may shift a major area of potential suitable zones for various horticultural crops. Studies conducted at IISR, Calicut using GIS models have shown that many suitable areas of spices will become marginally suitable or new areas, which are presently unsuitable, become highly suitable for cultivation of spices. This holds good to a variety of horticultural crops, such as citrus fruits, medicinal plants grown in hilly zone of West Bengal.

Production timing is likely to change. Because of rise in temperature, crops will develop more rapidly and mature earlier. For example, citrus, grape, melons and mangoe will mature earlier by about 15 days.

While temperature rises, photoperiods may not show much variation. Onions, a photosensitive cop, will mature faster leading to small bulb size. Strawberries will have more runners at the expense of fruits.

As the winter regime and chilling duration reduce in temperate regions, they will affect the temperate crops.

The faster maturity and higher temperature induced ripening will make the produce, especially fruits to have less storage period in trees/ plants. They will overripe.

Pollination will be affected adversely because of higher temperature. Floral abortions will occur.

Soil temperature will increase much earlier in spring hence the planting time also will advance. This can be catastrophic if late frosts occur.

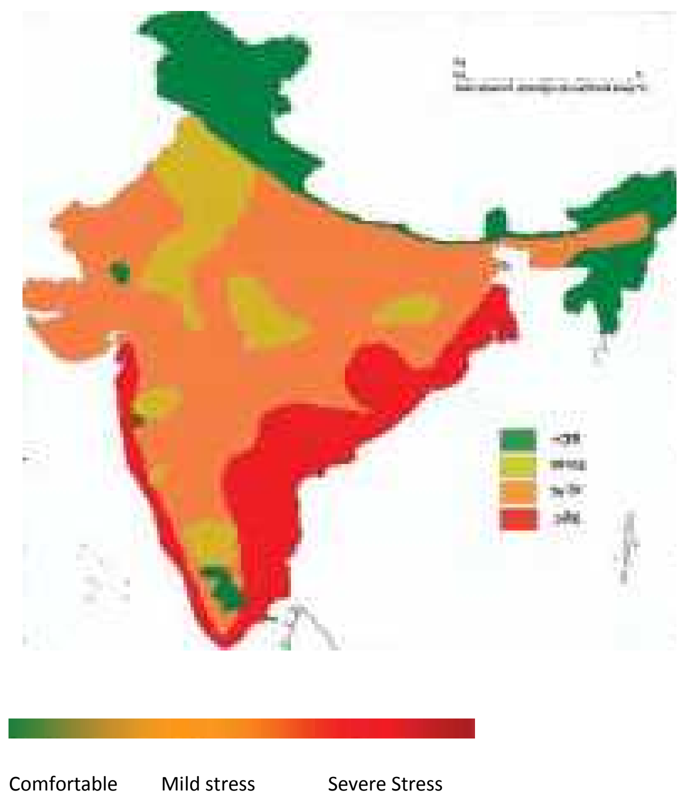
The requirement of annual irrigation will increase, not only because of higher evaporation, but also because the trees develop more fasters during the 12 month period. Heat units required will be achieved in much lesser time.

Higher temperature will reduce tuber initiation process in potato, reduced quality in tomatoes and poor pollination in many crops. In case of crucifers, it may lead to bolting; anthocyanin production may be affected in apples and capsicum. Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier. Tip burn and blossom end rot will be common in tomatoes.

Soil conditions may pose problems with an increase in acidity, alkalinity and salinity are expected. Coastal regions can expect much faster percolation of sea water in inland water tables causing more salinity.

Live stock

Livestock Productivity: The Temperature Humidity Index (THI) relates animal stress with temperature and humidity. Livestocks are comfortable at THI between 65 and 72, under mild stress when THI is between 72 to 78 and under severe stress when it is above 80. The average THI for different places in India is shown in Figure 8. The livestock in West Bengal is already experiencing medium to high stress levels. Increase in temperature levels in the future may make the entire West Bengal region with THI > 80.



Studies carried out by NDRI, Karnal reveal that livestock, especially cattle and buffalo are likely to suffer from heat stress impacting their productivity. Similarly small ruminants and poultry also are like to be affected and loss in their productivity is expected (see box 2). Some of the impacts on cattle and buffalo are listed below.

Impact on production systems: There is normally a decrease in milk production for animals under heat stress. This decrease can be either transitory or longer term depending on the length and severity of heat stress. These decreases in milk production can range from 10 to >25%. It has been estimated that with a temperature rise of 1.0 or 1.2°C with minor change in precipitation during March – August, (Region 23- HADCM3 A2/B2 scenario) milk productivity is likely to be marginally affected and during other months productivity will remain relatively unaffected. The negative impact of temperature rise on total milk production for India has been estimated about 1.6 million tonnes in 2020 and more than 15 million tonnes in 2050.

An average adult cow or buffalo producing 10-15 lit milk per day requires about 40- 45 lit/day as drinking water on hot days and about 40- 60 lit for other related work thus requiring a minimum of 100 lit/ day/ animal. An organized animal farm following standard management practices and disposal of animal wastes requires additional water about 50- 100 lit/day/animal. Any loss in water availability will certainly lead to decline in milk productivity.

Impact on animal growth and reproduction: Heat stress due to temperature or temperature -humidity impairs reproductive functions and efficiency of almost all livestock species. Various studies have shown that heat stress challenges the reproductive performance of cattle and buffaloes (*Upadhyay, R.C., Ashutosh, Raina,V.S., Singh, S.V. 2009. Impact of Climate Change on Reproductive Functions of Cattle and Buffaloes.In, Global Climate Change and Indian Agriculture – Case Studies from the ICAR Network project, edited by P.K. Aggarwal, 107-110*) such as altered follicular development. Further, possible climatically associated shifts in animal breeding time and offspring born could occur in cattle and buffaloes under different agro-climatic conditions. Rising temperatures negatively impact growth and time to attain puberty of livestock species, it is likely to slow down from a growth rate of 500g/day or more to 300-400 g/day of growing cattle. Crossbreds are more sensitive to rise in THI than indigenous varieties. Analysis of the potential direct effects of climate change and global warming on Murrah buffaloes indicated that a temperature rise of more than 2°C over existing temperatures in 2050s will cause higher incidence of silent estrus, short estrus and decline in reproduction efficiency of buffaloes. Such impacts are also expected on indigenous cattle varieties in West Bengal

Impact on physiological responses and functions: The sensitivity of livestock to increasing ambient temperatures under open ambient conditions and in climatic chamber have been evaluated by exposing Zebu, crossbred cattle and Murrah buffaloes to warm/hot ambient temperature (26-40°C) and low/cool temperatures (6-16°C) at NDRI Karnal. Body heat storage increased beyond their capacity to tolerate heat particularly on days, when THI exceeded 80 during summer and hot-humid conditions. The study also revealed that Zebu animals under hot dry/hot humid conditions have better heat tolerance than crossbreds or buffaloes. The sensitivity of buffaloes to temperature rise above 35°C was observed to be higher than either Zebu or crossbreds. The physiological responses, such as respiratory frequency, heart rate and energy expenditure doubled or trebled for an increase of 1.0°C in temperature.

***Effect on feed and fodder availability*:** Water scarcity not only affects livestock drinking water resources, but also it has a direct bearing on livestock feed production systems and pasture yield. Rising temperatures also have an additional impact on the digestibility of plant matter. Raised temperatures increase the lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species. This not only affects the health of an animal but also results in the reduction in livestock production which in turn has an effect on food security and incomes of small livestock keepers. Studies have shown that dry matter intake decreases in animals subjected to high temperatures. This depression in dry matter intake can be either short term or long term depending on the length and duration of heat stress.

In West Bengal there is already a severe shortage of feed and fodder. The fodder requirement is around 615 MT/year, as against this, availability is only 248 MT (40%). The area under permanent pastures and other grazing land is less than 0.1 per cent of the. Total reporting area under fodder land is only 1.08% in West Bengal. There is acute shortage of good quality fodder seeds in the State. The two main feed ingredients viz., maize and soybean are required to be imported from other states.

Animal diseases and livestock health: Climatic conditions favourable for the growth of causative organisms during most part of the year due to temperature rise will facilitate spread of diseases in other seasons and also increase area of spread. Higher temperatures and changing rainfall patterns can enhance the spread of existing vector borne diseases (Bhattacharya et al, 2006) and macro parasites, accompanied by the emergence and circulation of new livestock diseases. Climate change will modify the dispersal, reproduction, maturation and survival rate of vector species and consequently alter viral and bacterial disease transmission. In some areas, climate change is likely to generate new transmission models. Temperature and humidity variations could also have a significant increase in helminth infections, protozoan diseases such as Trypanosomiasis and Babesiasis. Some of the viral diseases (PPR or RP like diseases) may also reappear affecting both small ruminant population as well. Frequency and incidence of mastitis and foot diseases affecting crossbred cows and other high producing animals may increase due to increase in number of stressful days.

Wide spread animal disease in West Bengal is mainly due to Low hygienic standard, Improper housing, Malnutrition, and Inadequate veterinary facilities vis-à-vis livestock population

Box 2: Impact of climate change on poultry in India

As the ambient temperature reached ≥34°C the mortality due to heat stress was significantly high in heavy meat type chickens (8.4%) as compared to light layer type (0.84%) and native type (0.32%) chickens. Feed consumption decreased from 108.3 g/bird/day at 31.6°C to 68.9 g/bird/day at 37.9°C. Egg production also decreased both in broiler (by 7.5%) and layer (by 6.4%) breeders as compared to their standard egg production. The body temperature increased from 41 to 45°C as the shed temperature rose from 28 to 42°C and the critical body temperature at which the birds succumbed to death was 45°C, which was observed at the shed temperature of 42°C. Naked neck birds performed significantly better than the normal birds with respect to thermotolerance, growth, feed efficiency and immunity at high temperatures.

Strategies and Actions for Adaptation to Climate Change

Crops

The general strategies that are applicable for ensuring adequate crop productivity and ensuring associated livelihoods in West Bengal would include:

- Crop diversification needs to be done by introducing alternate production systems in the 6 agro-climatic zones, that effectively exploits the climate, soil and water resource availability in the context of climate change. This can be done through exploitation of the biodiversity and encouraging diversification to new crops that are a part of the biodiversity of the zone, and also by enhancing activities under Integrated scheme of Oilseed, Pulses, Oil Palm and Maize (ISOPOM). In the upland in Red and Lateritic Zone of WB, where there is no impounding of rainwater, maize, black gram, pigeon pea, millets can be grown as sole/ intercrop. In the pre-monsoon season, areas receiving >100mm rainfall can be cropped with greengram and blackgram. In upland, i.e hill and terai zones, cultivation of Goundnut, maize, sorghum, soybean, blackgram and greengram needs to be taken up instead of rice. More outreach required to train farmers on alternate crops.

- Introduction of new cultivars of rice, and other important staple crops that are heat resistant, can endure water stress, tolerant to salinity of the soil, and are fortified with nutrients for growing in soils deficit in corresponding nutrients. Introduction of short duration wheat can be one adaptation strategy to overcome the rising winter temperatures.

- Encouraging indigenous cultivars that are more hardy with respect to vagaries of climate and more nutritious such as small millets, and other cereals, pulses and oil seeds

- Upscale Resource Conservation Technologies (RCTs) for farming such as “no tillage" as it saves water, labour and energy, helps early sowing, improves soil organic C, reduces soil compaction, increases fertilizer use efficiency, and reduces soil erosion.

- Water harvesting through ground water recharge using runoff from hills in red and Laterite zone.

- Introduction of drip irrigation in Red and Laterite zone.

- Water conservation for rice production can be significantly enhanced by introducing aerobic rice, direct seeded rice, and SRI technologies such as keeping the fields moist, not flooded, planting of singe plant adequately spaced to permit more growth of roots and canopy and to keep all leaves photosynthetically active; and rice seedlings are transplanted when young, to avoid trauma to roots and to minimize transplant shock.

- Introduce farm mechanisation for planting technologies such as bed planting for rice and wheat and drum seeding for direct seeding.

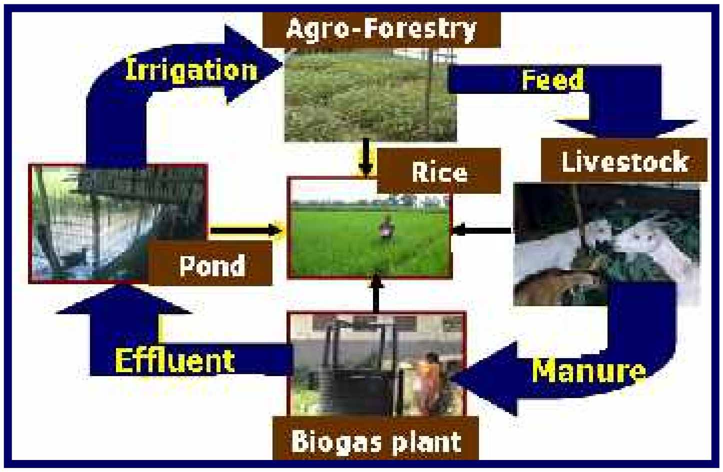
- Additionally, brown manuring can also be done for resource conservation as it is a ‘no-tillage’ version of green manuring, using a non-selective herbicide to desiccate the crop (and weeds) at flowering instead of using cultivation. The plant residues are left standing. This may also be a preferred option on lighter soils prone to erosion. The standing residues can be grazed after appropriate withholding periods have been observed. Further sequential cropping can be practiced.

- Introduce sequential cropping of different crops, that can also augment nutrient into the soil for the next crop.

- Nitrogen management through LCC in puddled and direct seeded rice: Leaf Colour Chart (LCC) to determine the nitrogen status in growing rice in direct seeded/ transplanted

/Zero Tillage (ZT) rice. The timings of nitrogen top dressing could easily be determined based on soil N supply and crop demand. This simple tool helps farmers to reduce the excess use of nitrogen fertilizers and leads to fertilizer savings of up to 46 kg N /ha.

- Popularise the concept of Integrated Farming System (IFS) that integrates, rice crops, livestock and fisheries. For example, the livestock can provide the manure, which can be used for producing energy. The effluent of the biogas system can be the manure for the fields. The water on the fields can support fisheries. Rice stock can be cattle feed. Broken rice grain for poultry feed. IFSs with different types of elements of integration can be developed as per the suitability of a region.



Integrated farming systems

- Undertake effective soil nutrient management, to counter the deficiency of soil nutrients across the state - application of right nutrient, right time and right place for minimum costs. For example, in terai region due to leaching there is deficiency in lime, Zinc and Boron. Further, it seen that by green manuring such as enrichment of the soil organically by growing a variety of crops on the land and then ploughing the green matter back into the soil it is possible to enrich the soil in 200 days .

- Develop biological ways for combating weeds, insect, pests and diseases and nutrient management. For example, green manuring incorporates green plant residue into the soil with a cultivation implement. Most commonly conducted with an offset disc plough, cultivation aims to kill weeds and control seed-set while building soil organic matter and nitrogen status. Green manuring has a very long history of managing weeds and building soil fertility in systems where herbicides are either not an option or not available, such as organic farming systems.

- Strengthen research and development for
    - water resource conservation technologies
    - developing new climate proofed cultivars
    - nutrient management
    - organic pest management
    - Identification of crops for crop diversification
    - Identification of traditional hardy, nutrient rich crops appropriate for each zone

- Effective outreach for advisory to farmers on various aspects of agriculture including setting up systems to access real time weather and 7 days forecast and long term forecast; strengthening outreach through agricultural BPOs for accessing information on forecasting on climate (7days forecast, advent of monsoon, and projections on rain fall and temperature for the entire cropping season- on choice of cultivar, time of cropping, likely crop diversification, type, method, time and quantity of farm inputs; promote use of internet and mobile telephony.

- Develop seed storage facilities in red and laterite areas where the moisture is the least. The aim is to establish a seed bank in this region which will make available seeds for contingent situations and also develop infrastructure for seed storage. The salient features would be the establishment of seed bank for maintenance of foundation and certified seeds of different crops to ensure timely availability of seeds to the farmers, to take care of the special requirement of seed at the time of natural calamity and to create infrastructure facilities for production and distribution of quality seeds. The seed bank will be established according to the guidelines of the national scheme on development of seed banks and supported by the West Bengal State Seed Corporation. Further, seed banks at village/community levels also need to be encouraged.

- Access to funds for farmers to enable them to develop market ready products such as dal thrashers and oil mills.

- Expand the coverage of crop insurance to small and marginal farmers in the state. In order that the benefits of Crop Insurance can reach the actually affected farmers, insurance of two most important crops in the State – Aman and Boro rice have been notified at the Gram Panchayat level since 2002-03. The other crops insured at block level in West Bengal are Jute, Aus rice, Maize, Wheat, Mustard; and those insured at the district level are Musur, Gram, Maskalai, Arhar, Mung, Linseed and Til. In the Rabi season of 2008-09, 6.43 lakh farmers insured their crops, of whom 6.41 lakh were small and marginal farmers. The total area covered was 3.40 lakh hectares with total sum insured amounting to Rs.982.10 crore. The amount of premium paid was Rs.3953.74 lakh. The total subsidy paid by the Central and the State Government was Rs.3694.56 lakh of which state's share was Rs.1847.28 lakh.

- Enhance access to markets by building infrastructure for transferring produce and storing grains in block levels in West Bengal.

- Encourage public-private partnership for easier penetration of all strategies for fortifying productivity and food security and for enhancing earnings of the marginal farmers.

Fisheries

The main aim of the Government of West Bengal is to ensure productivity of fish even in the context of climate change. Hence the following strategies have been put forward to ensure the same.

- *Real time Monitoring of Fish shoals:* Monitoring of Fish Shoals is necessary to assess the quantum of fish arriving per shoal at different level of river and sea-water and at different time period. For this 1 (one) Deep Sea Monitoring –cum Research vessel equipped with state of the art technology may be hired from other Govt. Organizations. Further throughout the stretch of River Ganges from Sagar to Farakka at least 40 Nos. of Monitoring Cell (21 for Riverine, 6 for estuarine & 7 for Fishing Harbours and 6 for Fish landing centers along the coastline of West Bengal) equipped with modern facilities should be constructed. Every unit may be operated by a 5 (five) member team.

- *Real time Weather Monitoring & Forecasting:* It is one of the vital parameters for gaining maximum /optimal production of fish and fish seed as the climatic parameters (Temperature, Humidity, Rainfall, Water flow, Sea-surface temperatures and water level) are directly associated in maintaining fishery resources properly. For this a meteorological unit at all districts headquarters (Meen Bhavan Complex) and places of importance from the point of view of inland and marine catch may be installed in 22 points across the State as per guideline of India Meteorological Department (IMD) and /or CSIR. This will cost around Rs. 506 lakhs. However, in 12th plan, real time data from Regional Meteorological Centre, Alipore, Govt. of India on yearly contract basis for the data of stations/districts and places of importance from the point of view of Fish and Fisheries @ Rs. 1.0 lakh per year per can be accessed. Total cost will be Rs.110 lakh.

- *Mapping vulnerable fisher folk settlements:* Identifying vulnerable fisher folk residing in and around inland and marine villages is a matter of deep concern. Through the system of Remote Sensing and Geographical Information Systems they may be located them and project new outlook for their all round socio-economic development. Location and mapping of the helpless fisher folk throughout the state may be done at gram panchayat level. Qualified personnel on contractual basis may be deployed to collect such data from G.P. Level in conformity with the data of Census Department. Govt. of India and GIS data attained from zonal officers of Dy. Directors and to synchronize such data in computer.

- *Forecasting and use of simulation Modeling:* The following factors will involve in generating a model for forecasting on fisheries viz. i) weather forecasting, ii) Testing of soil and water iii) Training on Fishery and fishing practices at grass-root level. In India, spatial marine fish catch and effort data are available for the last four decades. However, a synergy between the climatic and oceanographic data and fisheries data does not exist. Projections on climate change impact on fish populations are the first step for future analytical and empirical models, and for planning better management adaptations. Special thrust needs to be given for data generation. There may be gaps in attaining real time data on Fish & Fisheries. Disparities observed between the published report and actual physical observation is a matter of deep atrocity and such disparity occurs in course of data transition from lab to land and vice-versa. Data management in its proper sense should be taken into account to overcome the problem. The strategies for bridging the gaps include i)Adequate training to Fishery Officers' (from grass root level to District Level), ii) Engagement of qualified survey personnel (at least Science graduate) iii) Acquaintance of fishery personnel with modern equipments and computer systems iv) Random field visit and routine supervision by higher officers.

- *Mangrove Plantation:* There is a positive correlation between mangroves extent and total fisheries yield in the adjacent waters due to abundant supply and regeneration of nutrients due to the activity of microorganisms and filter feeders (Schelake and Odum 1962). The estuarine water is not only enriched with nutrients but it is perfectly buffered against abrupt changes in pH. Different types of bacteria in abundance in the soil, water, litter etc play the important role in nutrient cycle of this ecosystem. Mangroves resist soil erosion and protect the mainland from devastating storm. There should be a specific programme for mangrove plantation along the canals, ponds and other water bodies in the Hoogli Matlah estuarine region for the conservation of bio-diversity.

- *Promotion of brackish water canal fisheries:* Promotion of Brackish Water Canal Fishery and Creation of mangrove dyke plantations along the tide fed canals to prevent erosion as well as enrichment of nutrients of canal water through leaf fall. Further, Mangroves help to protect coast lines from erosion, storm damage, wave action. Protection and conservation of the natural environment and periodical excavation of the canals are being made by the local populace for their own interest. In Vietnam, a number of State Forestry-Fishery Enterprises (SFFEs) integrating shrimp & fish culture and mangrove forestry were developed in coastal communities of the Mekong Delta with an objective of rehabilitation of mangroves and income generation by the process of aquaculture. West Bengal has an extensive canal network of about 80,000 ha spread over different river systems with vast unrealized fishery potential out of which 23,430.47 ha is in the coastal districts covering 24 parganas (N), 24 Parganas (S) & Purba Medinipur (DOF, GoWB, 2003-04).

Table 6.4: List of Canals under South 24 Parganas District

Sl No	Name of the Block	Total area in acres.
1	Sagar	59.00
2	Patharpratima	287.87
3	Kakdwip	35.83
4	Namkhana	16.39

5	Mathurapur – I	9.40
6	Mathurapur – II	215.46
7	Kultali	112.39
8	Joynagar – II	214.69
9	Canning-I	20.55
10	Canning-II	7.00
11	Basanti	161.05
12	Gosaba	1055.99
13	Bhangore-II	15.20
14	Kulpi	30.50

- *Development of Sewage fed fisheries:* West Bengal has 0.41 lakh hectare of beels. owned by the Fisheries Co-operative Societies. Besides, 279 wastewater fed farms covering an area of approximately 5000 ha supply more than 21,000 MT of fish per year to the city customers. Protection of water and wetlands resources can be achieved by introducing fish in these areas to improve water balance, produce more oxygen and absorbing more carbon dioxide. The floodplain wetlands (beels) are considered as biologically sensitive habitats as they play a vital role in the recruitment of fish populations in the riverine ecosystems and provide nursery grounds for commercially important fishes as well as the endangered native fishes. Most of the large water bodies viz. Beel Baor Bundh etc. have become silted due to long years of neglect. It has been observed that the ecotonal zones of the wetlands have become extremely shallow (witnessed only 0.5-1.0 mt depth in average). This has resulted in overflowing of water from these water bodies causing flood with consequential loss of fish crop.

- *Providing Life Saving Equipments:* Losing a life of a fisherman in work is a serious concern. There should be specific plans to provide life saving equipment to the fishers. The equipments should be easy to wear and remove, maintenance free, hazard less and cost effective.

- *Protection and Development of Water Bodies:* Protection and development of water bodies is of utmost importance to combat climate change. Fisheries activities need to be popularised in both seasonal and perennial water bodies. Initiatives need to be taken to preserve the small water bodies by promoting endangered species. Protection and conservation of the natural environment and periodical excavation of the water bodies will be made by the local populace for their own interest. Small ponds in rural areas especially in Sunderbans regions will be re-excavated, reclaimed and renovated. About 500 hectors water with a unit cost of Rs. 1 lakh per hector will be brought under this scheme by the year 2020.

- *Promotion of Solar Light:* Tapping non-conventional energy resources by way of erection of solar light is very important in respect of adaptive measures for climate change.

- *Block level laboratory cum training centre for Fishery Extension Officers*: The Fisheries Department, Government of West Bengal took an initiative to expand its extension service upto grass root level by establishing Block level laboratory cum training center for Fishery Extension Officers. These establishments are the main hub of the training, demonstration of new technology, water and soil analysis as well as disaster management. In case of sudden occurrence of any type of climatic hazards these centres equipped with e-services can offer all type of assistance immediately.

- Research to ensure fish productivity and hence food security:
  - Endangered fish species
  - Fish virology and effect of pesticides on fishery
  - Survey of Migration route, biomorphological study and stock assessment of Hilsa & other species
  - Increased Productivity & Brood Stock Management in Departmental Farms
  - Species specific feed formulation for native threatened/endangered fish species through gut content analysis of the target species
  - Value added fish products
  - Impact of climate change on marine and coastal fish production of West Bengal & options for adaptive measures
  - Mass culture of different indigenous algal species on preparation of algal powder for ready to use fish feed & human supplementary feed

Horticulture

Considering that the temperatures are increasing and rainfall is becoming erratic, along with the changing pattern of soil nutrient, the productivity of horticultural crops are at stake. The basic climate and soil nutrient requirements for major horticulture crop are listed in Table 6.5. Any parameter above and below will jeopardise their productivity. Hence the follwoing strategies may be adopted to maintain the same level of productivity as well as enhance the same.

Table 6.5 . Soil and climatic requirements of horticulture crops

Sl No	Crop	Soil pH	Temperature(°C)		Rainfall(mm)/ water requirement(mm/ha)
			Min	Max	
1	Mango	5 to 7.5	21	27	750mm
2	Banana	5.5 to 8	15	35	300 to 700mm
3	Grape	5 to 8.5	25	35	300 to 750mm
4	Papaya	6 to 7.5	5	38	300 to 750mm
5	Pomegranate	6 to 8.5	25	35	300 to 750mm
6	Sapota	5.5 to 8	11	34	500 to 800mm
7	Annona	5.5 to 8	8	44	600 to 800mm
8	Guava	5 to 6	11	34	600 to 800mm
9	Jackfruit	6 to 7.5	25	35	1000 to 1500mm
10	Tomato	5.5 to 7	15	24	330 mm/ha
11	Brinjal	5.5 to 6.6	21	27	486 mm/ha
12	Chilli	6.5	20	35	640 mm/ha
13	Melons	6 to 7	30	35	450 mm/ha
14	Peas	5.5 to 6.0	10	18	240 mm/ha
15	French bean	5.5 to 6.0	15	25	300-350 mm/ha
16	Onion		20	25	500 mm/ha
17	Chrysan-themum	6.5to7.0	16	25	750 to 800 mm
18	*Jasminum sambac*	6.5	21	32	750 to 800 mm
19	Black pepper	5to 6	10	40	1500 to 3000mm
20	Cardamom	4.2 to 6.8	10	35	1500 to 5000mm
21	Ginger	5 to 7	19	28	15000 to 3000mm
22	Turmeric	4.3 to 7.5	18	30	640 to 4000mm

One of the challenges the horticulture production in the near future will be to increase high quality horticulture in marginal sites where the abiotic environment is the limiting factor. Supra and sub-optimal temperatures, soil factors and water deficits are the most likely environmental factors limiting production. A good integrated management strategy can include:

- Protection from heat in all zones below hill and terai zones: In the short run, provide over head shade to fruit trees and construct greenhouses for vegetables, wherever the temperatures are exceeding the tolerance level of plants

- Research: In the long run, introducing new varieties to ensure livelihood security of the poor relying on agriculture, focus should be on optimizing productivity with maximum profits. Research and Development will play a vital role in identification of new cultivars resilient to higher temperatures, water stress and high concentration of CO_2. Develop fruit and vegetable varieties that can adapt to excess salinity, can tolerate heat stress and water stress. Develop vegetable varieties that are fortified with nutrients that are absent inthe soils they are grown. Develop short rotation varieties of vegetables to adjust to the increasing winter temperatures

- Popularization of indigenous varieties: Mapping of existing traditional varieties practised by farmers in different regions are to be conducted and characterized having high resilience to the changing climate need to be identified and promoted.

- Crop diversification: Continue and intensify crop diversification programmes to include more crops which have wider adaptability. Improvement of existing practices of growing crops which are sensitive to climate resilient crops.

- Improve floriculture programmes: Climate change will definitely impact production of flowers. Promotion of protected cultivation of high value commercial flowers should be focussed. Provide support for greenhouses.

- Production of off-season vegetables: Off-season vegetables have very high scope for improvement of rural economy at higher altitudes where the temperatures are likely to remain conducive.

- Integrated Pest Management (IPM): Steps to be taken to replace chemical control of diseases and pests by bio-pesticides, bio-control agents and other organic methods. These programmes need to be intensified to expedite the process of organic conversion.

- Water management system: Undertake water management programmes to use efficiently water and provide critical moisture for crop health. Ongoing programmes such as drip irrigation, construction of rain water harvesting structures, community ponds are to be strengthened to increase productivity with limited water and simultaneously conserving rapidly diminishing water resources. Through efficient system of water management, it is targeted to utilise fallow land after paddy crop for cultivation of vegetables, potato and other horticultural crops during Rabi season.

- Reducing weather related risks: Establish weather stations at high spatial resolution for weather data collection at village level, analysis by near by agriculture university and forecasting the same. Sensitise the farming community on weather related risks. This system should also focus on helping farmers to make critical farming decisions for efficient crop management practices.

- Enhance infrastructure for storage and transport to markets of perishable horticulture products.

- Monitoring impacts of climate change: Information system within the department needs to be strengthened with focus on collection of baseline data and a system to measure changes periodically with climate change impacts

Livestock and Livestock Products

- Encourage breeding of small ruminants for livelihood security: The State is naturally gifted with a good stock of Black Bengal Goat, Garole Sheep and Ghungru Pig. The presence of high fecundity factor makes the breeds like Bengal Goat, Garole Sheep and Ghungru Pig for evolution in any adverse environment. Genetic up-gradation programme of Garole Sheep, Bengal Goat and Ghungru Pig involving SHGs in the State of West Bengal has to be given utmost importance.

- Therefore as a strategy for adaptation for small and marginal farmers who can afford the small ruminants , encouragement may be given for Goat Farming (Bengal Goat), Sheep Farming (Garole Sheep), Pig Farming (Ghungru Pig/ Improved breed), Broiler Farming, develop Meat processing plants, and undertake Male exchange programme of Black Bengal goat to arrest inbreeding depression

- Strengthen disease investigation system: Research studies to be conducted to study the causes of diseases related to climate and the nature of emerging diseases due to emergence of new pests and diseases and develop control measures by involving livestock research institutions.

- Preventive health measures: To control and contain the existing epidemic diseases, the government and its concerned departments need to prepare long term strategies where by 100 percent population of the livestock get regularly vaccinated. Beside this, animal health camps need to be set up in various occasions to make people aware of adopting different control measures.

- Improved cattle sheds for alleviating heat stress in livestock: The cattle sheds may be augmented with Water sprinklers or directly bathing the animals to enable them to have evaporative cooling, allow them to wallow in the ponds and other water bodies, increase the air circulation in sheds so that cool air is retained, undertake evaporative cooling;

- Feed and fodder development:. To combat fodder shortage, fodder development needs to have an additional impetus from the government by promoting mixed crop system, growing fodder on waste land, agro forestry etc. These may be further enhanced. It may also think of supporting farmer centered fodder banks. Undertake mineral mapping in different regions to assess mineral status and accordingly supply specific mineral mixture to farmers for growing fodder.

- Dairy Development: For enhancing the milk productivity even with increase in temperatures, extensive Artificial Insemination of the indigenous stock of the State has to be undertaken. .

- Risk Management: Coverage of agriculture insurance may be extended to animal husbandry as well, especially for small and marginal farmers. Feasibility of the same needs to be studied before it can be launched. Other forms of risk management for farmers can be explored.

- Capacity building of farmers for effective adaptation to climate change: Adaptation practices vis a vis right shelter for animals to protect them for heat stress, right grazing practices that would enable the animals to be protected from heat, the practices for identifying disease and mitigating them, creating feed mixes with proper nutrients for enhancing mild productivity, etc.

See Table 2, 3, 4 and 5 in Annexure 1 for strategies, actions, timelines and budgets for adaptation to climate change in for crops, livestock, horticulture, and fisheries.

7. Forests and Biodiversity

Introduction

The forests in West Bengal cover just 2.7% of the Indian landmass but it is home to 12.27% of Indian biodiversity known till date. The state has more than 7000 species of described flora including bacteria, algae, fungi, bryophytes, pteridophytes and angiosperms and more than 10000 species of described fauna. It has a rich resources of traditional knowledge for conservation and information associated with these bioresources. The state's rich and living traditions are typically folksy in character and are closely related to the area's topographical conditions.

Some of the prominant wildlife animals that have their habitats in West Bengal include, the Royal Bengal tiger, clouded leopard, Red Panda, Batagur Terrapin, Goliath Heron, Leopard, Jungle cat, Olive Ridley turtles, marbled cats, Bengal Florian, Fishing cat, Indian elephant, , Pygmy hog, esturine crocodile, Gaurs, leopard cats, spotted deer, assamese macque, Great pied hornbill, Pythons, Black necked crane, Ganges river dolphin, Himalaya Black Beer, Indian Rhinoceros, Barking deer, Serow and King Cobra.

Hundreds of species of Asteraceae, Poaceae, Leguninoceae, Roseceae, Scorphulariaceae, Rubiaceae, Euphorbiaceae, Cyperaceae and Saxifragaceae represent 10 dominant families of angiosperms in the area. About 40% of total Himalayan flora is endemic with the majority occurring in the eastern flank.

Of the gymnosperns, 15 species occur in Eastern Himalayas with at least 5 genera being confined to the region. Of the ptendophytes (fern and fern allies), 70% of polypodiaceous taxa of India are concentrated in Eastern Himalaya.

Nearly 50% of more than 2000 moss species are known from the region. Of the liverworts, more than 320 species are known from the region with a high percentage of endermism. At least 728 taxa out of 2000 species known from this country occur in the Eastern Himalaya.

The Eastern Himalayan region is also well-known for medicinal and aromatic plants of the genera Aconitum, Asparagus, Berberis, Loscorea, Ephedra, GentIna, Hedychurum, Inula, Prunus, Rheum, Rosa, Saussurea, etc. 82 species of crop plants of Eastern Himalaya is also well documented. Due to increasing loss of habitat and impact of human activites, a large number of species are becoming vulnerable or threatened.

The richness of floral diversity could be appreciated from the point that West Bengal occupying only 2.7% of total area of India possesses more than 12% of floral diversity in angiosperm (flowering plants) in the area outside Dooars and Darjeeling Himalaya

West Bengal has diverse forest types as it extends from alpine climate in the Himalayas in its North to tropical climate in the Southern coastal region.

Rapid rise in population in the last one century, and its developmental needs have lead to the conversion of large tracts of forests to agricultural land and to other land uses. As a result the forest cover in West Bengal is sparse (14.64% of the total area), which , ideally should have been around 33% of the geographic area (National Forest Policy, GOI). Inspite of the socio-economic pressures, about 10 diverse forest types exist in West Bengal. The details of the forest types and their location in different districts along with area covered is shown in Table 7.1. Northern tropical dry deciduous forest area dominates, follwed by littoral and swamp forest in the Indian Sundarban region.

Table 3.7: Areas under forest in different districts of West Bengal

Forest type	Location	Area km^2	Principal trees spp.
1B-Northern tropical wet evergreen forest	North Bengal Plains and foothills	167	Shorea, Mesua, Eugenia, Bischofia Artocarpus spp., Cinamommoum spp., Amora spp. etc.
2B-Northern Subtropical semi-evergreen forests	North Bengal foothills	25	Michlia, ailanthus, Terminalia spp. Phoebe etc.
3C-North India moist deciduous forest	North Bengal Dooars and Terai	1757	The most important forest zone of the state is situated in this sub-montane tract consists of Shorea, Mesua, Terminalia spp. Schima, chuckrassia, amoora, cedrela etc.
4B-Littoral and swamp forest – mangrove forest of the	Ganga, Brahmaputra, deltaic region of Sundarbans	4263	Ceriops spp., Excoecaria, Avicennia, Heritiera sp., xylocarpus, carapa spp. etc.
4D-Littoral and swamp forest – seasonal of the	Malda and Dinajpur district	20	Barringtonia sp.
Northern tropical dry deciduous forest	Bankura, Purulia, Midnapore, Burdwan and Birbhum district.	4527	shorea, Pterocarpus, Diospyrus spp., Madhuca, Terminalia, alaca, T-belirica, T- aurjuna, Butea spp.
8B-Nothern sub-tropical wet hill forests	North Bengal Hill 300-1700 mt	800	Englehardtia spp. Schima, Castanopsis sp., Betula etc.
11B-North montane wet temperate forest	North Bengal hills 1600 -3000 mt.	150	Michelia, Machilus, Alnus, Exbucklandia, Betula and Acer sp.,
12C-East Himalayan moist temperate	North Bengal hills	150	Exbucklandia ,Englehardtia spp.

forest	1500-1800 mt		Schima, Castanopsis, Betula sp., T.myriocarpa., Duabanga spp., Acer, spp.
14C-sub alpine forest	North Bengal hills 3000-3700 mt	20	Acer, high altitude oaks, Prunus and several conifers, eg. Taxus, Tsuga, Abies, Juniperus, and high altitude Betula, Rhododendron spp. and Arundinaria spp. and other high altitude Bamboos.

Currently the forest cover of the state is around 12,994 km2 which is 14.64% of the states geographical area. Comparison of the current forest cover (i,e as of Oct-Dec 2006, as published in State of the Forest Report, 2009 of the FSI), with that of Nov-Dec 2004 shows a gain of 24km2 of forest cover. In terms of forest canopy density classes, the state has 2,987 km2 of very dense forest cover , 4644 km2 is moderately dense forest, and 5363 km2 is open forest (See Figure 7.1). The change matrix indicates that there has been a decrease of 5km2 in very dense forests and 2km2 decrease of moderately dense forests and an increase in 31km2 of open forests has occurred. The increase in forest cover has occurred in the districts of Bankura, Birbhum, Bardhaman, south 24 Pargans's, Jalpiguri, and Medinipur due to protection of Sal coppice and plantation of acacia, Eucalyptus and Casuarina in the coastal areas.

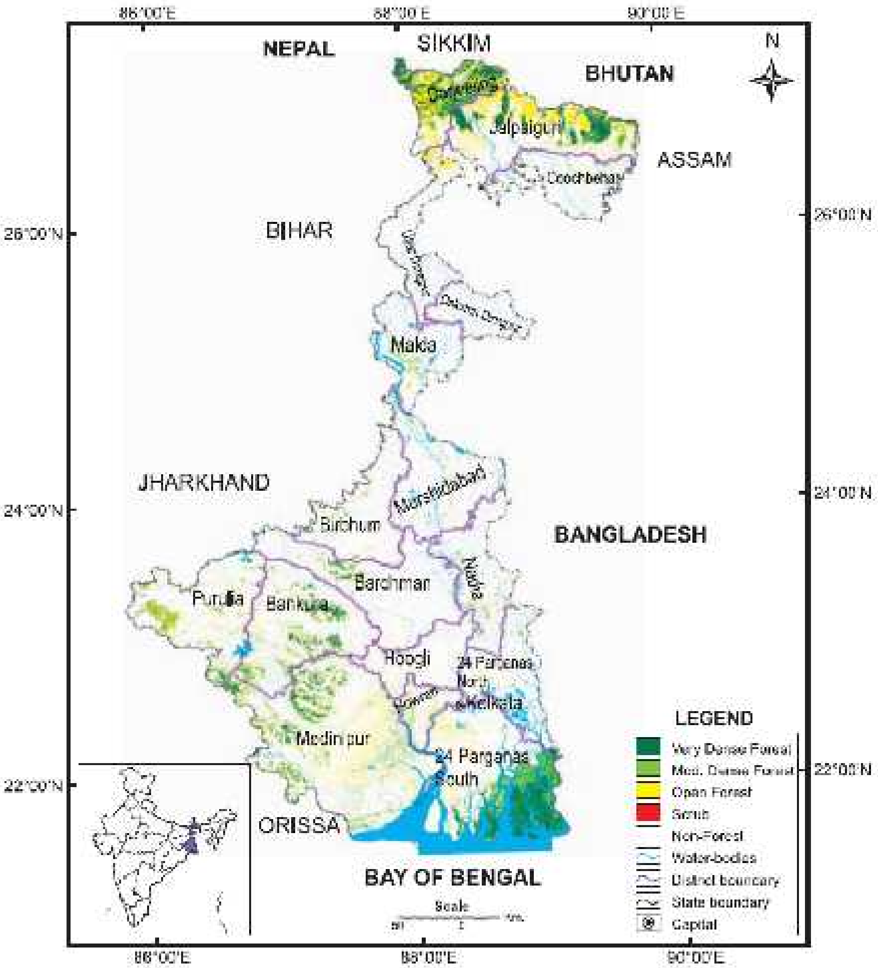


Figure 7.1: Forest Cover Map of West Bengal.
Source: State of the Forest, 2009, Forest survey of India

Institutions Involved and Current programmes and policies to protect forest and biodiversity in the state

The Department of Forest, Government of West Bengal is responsible for overall management of Forests and wild life in the state. The department promotes activities related to Eco tourism, soil conservation, supports research and development, It undertakes afforestation activities(see table 7.2).

Table 7.2: Scheme wise afforestation activities in 2006-2007

Sl.No.	Plantations/Scheme	Plantation Raised (Ha.)	Notional Area of Seedling Distribution (Ha.)
1	Quick Growing spp.	775	-
2	Economic Plantation	30	-
3	Protective Afforestation	232.5	-
4	Eco-conservation	41.5	-
5	Forestry Treatment	274.5	51.6
6	Strip Plantation (Deptt.)	559	-
7	Coastal Shelterbelt Pltn.	120	-
8	Elephant Project	240	-
9	Other Wildlife Schemes	240	-
10	Conservation & mgmt. of Mangroves	780	-
11	Establishment of SBR	50	-
12	Compensatory Afforestation	266.25	-
13	D.P.N.	-	505
14	Farm Forestry	-	630.2
15	Grants in Aid	75	76
16	Consolidation of J.F.M. and Enrichment of Forest Productivity (W.B.F.D.C.)	2743.03	-
17	Development of Hill Areas	28.5	0
18	NTFP	52	-
19	SGRY	164	482.5
20	FDA	5232	
21	RSVY	1865.7	368
22	Social Forestry Project	105	-
23	Greening of Rural Areas	4.5	-
24	Others	59	99.5
25	Mangrove Treatment	50	
26	R.V.P. Teesta/ DVC	405	
27	NFFWP	150	282
28	RIDF	110	
29	NREGS	880	694
	TOTAL	**15382.48**	**3188.8**

The main thrust in the field of forestry in the State is on the improvement of forest trees and productivity of forests. Species introduction trial has been considered as another method of improving the forest quality of the State. In this trial, species exotic to this country are being introduced and propagated in suitable environment and particularly where indigenous species fail to thrive. Recently Silvicultural nurseries have been given special attention. Modernization of nurseries have been done by improved irrigation system using automated misting apparatus and sprinkler to provide best facilities for clonal as well as seedling propagation. Large-scale application of bio-fertilizer and compost, which are eco-friendly, is promoted for raising field plantations. Organic manure is being preferred in place of inorganic fertilizers and it has proved its efficacy in field trials.

The West Bengal Forest Development Corporation Ltd. operates under the Department, and is regulator of large scale harvesting of forest produces, creation of new eco-tourism centres, production and marketing of forest products and such allied activities. The administrative set up of West Bengal Forest Development Corporation Limited is headed by the officers of the Forest Directorate on deputation.

For intensive management of Wildlife of the State, a new post of Principal Chief Conservator of Forests, Wildlife and Biodiversity has been created alongwith a separate Wildlife Wing. He is assisted by one Additional Principal Chief Conservator of Forests. Almost 34% of the total forest area, consisting of a number of Wildlife Sanctuaries, National Parks, Biosphere Reserves and Tiger Reserves, is under the Protected Area Network.

The gamut of activities of the Forest department and its subsidiaries include development of working plans, silviculture operations, protection and monitoring, developing afforestation plans and nurseries, soil and moisture conservation works. and Joint Forest Management. To ensure, public participation in management of Forests the WB government has set up Forest Protection Committees, Eco development Committee's, and Self Help Groups constituting of communities that are dependent on forest products in Red and laterite zone, hilly areas and in Saline coastal areas.

Under the "Integrated Forest Protection Scheme" sponsored by Government of India, The WB government is protecting forests from fires. The works preformed under the scheme is to sensitize the Forest Protection Committees (FPC) about the ill effects of fire and fighting of fire along with local staff of the area, creation of water sources such as earthen dams, other soil moisture conservation structures, wells etc. which would on one hand benefit the FPC and help to fight fire in the area on the other, creation of new firelines and maintenance of old ones etc. Besides above, watch towers are constructed at strategic locations and fire watchers are also engaged during the fire prone season for tracking of fire earlier. See Table 7.2.

Table 7.3: Forest Fires in 1996-2007 in West Bengal

Division	No. of cases	Area affected (ha.)	Estimated loss (Rs. in lakhs)
Bankura (North)	11	118.00	0.30
BTR (E)	2	3.50	-
Burdwan	1	5	-
Cooch Behar	3	50	-
Darjeeling	6	51.90	-
Durgapur S.F.	6	32.50	0.79
East Midnapore	5	526.65	4.64
Jalpaiguri	4	28.095	-
Kurseong	26	43.15	0.40
Kangsabati – I	1	2	0.10
Kangsabati – II	1	10.00	0.50
Kalimpong (G & S)	5	105.75	-
Panchet S.C.	3	8.00	0.05
Wildlife - I	72	625.00	1.58

Likely Impacts of Climate Change on Bidoversity and Forests in West Bengal

Shift in Vegetation Type: A modelling study carried out in 2004 (NATCOM, 2004), using BIOME vegetation model with inputs from a climate change scenario derived from IPCC IS92a, indicates that in the West Bengal region, as increase in precipitation is expected, a shift in vegetation type towards the wetter, more evergreen type is expected. Since these are rather slow growing, the replacement will take much longer, and increased mortality in the existing vegetation may lead to a decrease in the standing stock except in the Western part of the state near Purulia and Birbhum where the vegetation type may become xeric. Even if there is no drastic shift in the biome type, changes in the composition of the assemblages are are certainly very likely. Thus few species may show steep decline in population and perhaps may become extinct. This in turn will impact other taxa dependent on the different species (i.e domino effect) because of the interdependent nature of the plant-animal-microbe communities that are known to exist in the forests ecosystems. This could lead to major changes in the forest biodiversity.

Net Primary productivity : The net primary productivity of the forests is likely to increase.

Impact on wild life: Qualitative conclusions drawn from the likely changes in biome and vegetation type, is likley to impact wildlife species by impacting their habitats, especially that of several high altitude mammals including red panda in West Bengal. An increase in precipitation in the future scenario at the middle and at the end of the century may lead to severe flooding in the Himalayan region, and may place the wildlife in the protected national parks at risk. similarly, the Himalayan medicinal plants will be at risk due to increase in temperature, and therefore need intensive research and development of species that can bear the heat stress and still retain the characteristics for which they are sought after. Also the rich flora of the Himalayan region, may be threatened due to increase in temperature. Flowers like the orchids, are very sensitive to the temperature and moisture content of the atmosphere, and therefore any change in the same would jeopardise their existence.

Impact on mangroves in Sundarbans: Further due to more discharge of water in the Ganga, it might effect the Sundarbans Mangroves that are more accustomed to the saline water. Therefore species, that are tolerant towards sweet water may also have to be planted in the forest towards the inland side to cope with the rush in sweet water.

Forest fires: The other apparent impacts of climate change may be increase in forest fires, as the temperatures increase. Managing forest fires will be a challenge in the future.

Increase in land slides in the Hilly region: Climate change, bringing more frequent intense rainfall may exacerbate the land slides across the mountains of Sikkim.

Changes in timing of seasonal events: Phenology is the study of changes in the timing of seasonal events. As temperatures increase, spring and summer events are advancing in time. Evidence includes early leafing, fungal fruiting, bird egg laying, spawning of amphibians, arrival of migrants and insect emergence. Autumn events are occurring both earlier and later in the year, and the trends are less clear.

Impact of increasing concentration of CO2: Increase in CO2 concentration with accompanied temperature alter the Crop-weed competition depending upon their photosynthetic pathway.

C3 crop growth would be favoured over C4 weeds. increase may alter the competition depending upon the threshold ambient temperatures. Diseases and insect populations are strongly dependent upon the temperature and humidity. Any increase in them, depending upon their base value, can significantly alter their population, which ultimately results in yield loss. With small changes, the virulence of different pests changes.

Impact on forest soils: The impact of increased temperature and precipitation change on forests is through their influence on soil processes and properties. Terrestrial ecosystems appear to be storing increasing amounts of carbon, largely attributed to increasing plant productivity due to elevated CO2 concentration, increased temperature and soil moisture changes. The soil carbon pool may be released as a result of warming and lessen due to less biomass accumulation in the soils. Also change in nitrogen content of the soil is likely.

Impact on livelihoods: The tribal population, especially in the Red and Laterite region, dependent on forests and its products may be affected due to shift in vegetation type in this region. some of the forest products that are being extracted for livelihood are wood products such as timber, bamboo, and fuel which go in the paper mills, match factories, coal mines and other industries. Non wood products include Honey, wax, sal seeds, leaves, kendu leaves, lac, sabai grass tassar silk, mohua, mushrooms, citronessa grass which are used as foodproducts. in industries. for making dyes and varnishes, alcoholic beverages, deed oils, fruits and vegetables and medicines. Some agricultural crops that are grown around forests are cotton, til, mustard, and turmeric.

Increase in man and animal conflict: Climate change may adversely alter the production of biomass and fruits on which the wild animals thrive. As a result, the animals may come in direct conflict with man outside the forests. In West Bengal, man-animal conflict consists of direct encounters and human casualties by elephants in the Northern hill region and Royal Bengal tigers in the sundarbans region.

Impacts on access to energy: Again the population living in the forest fringes in the Red and Laterite region and also in the Himalayan region may no longer have access to enough firewood for their cooking and heating purpose.

Sequestration potential of forests: If climate change brings in slow growing broad leaved vegetation, then sequestration potential of CO2 of the forests is likely to increease, provided the forest area also substantially increases as envisaged in the national forest policy.

Strategies to address climate change Impacts

The Government of India has recently launched the Greening India Mission aimed at mitigation and adaptation. The mission is meant to enhance ecosystem services such as carbon sequestration and storage, biodiversity conservation and provision of biomass and NFTPs. The mission aims at responding to climate change by a combination of adaptation and mitigation measures with the aim towards enhancing carbon sinks in sustainably managed forests and other ecosystems; adaptation of vulnerable species/ecosystems to the changing climate and adaptation of forest dependent communities.

Planning commission, recently has put forward its perspective in management of environment and ecology, and which includes adaptation to climate change impacts and mitigation of climate change. As regards, forestry, it maintains that the livelihood rights of forest-based communities need to be respected in conservation efforts, even as new livelihood and revenue options are explored. some of the key issues that it is looking into are the current schemes of compensation, Payments for Environmental Services (PES) that need to be introduced in various schemes, where by locals will be compensated for conservation and management of resources. It is also looking towards integration of proposals to prevent poaching of flagship species like tiger, rhino, elephants, etc. Also it aims to to check fragmentation and degradation of wildlife habitats and corridors, reduction in human–wildlife conflict; control illegal trade in wildlife products; Creation of inviolate areas for tiger and other flagship species, and; Voluntary relocation of people from core areas. In PES schemes, locals be paid to conserve and manage resources.

Based on the concerns in West Bengal about, a set of 9 strategies have been devised which are also in line with the Green India Mission and the perspectives of the planning commission in managing the environment and ecology. The strategies thus proposed are:

1. ***Spring recharge and enhancing ground water recharge in forest areas:*** The aim of this strategy is to make the Northern hill region and the Red and laterite region water secure areas in the state through appropriate management of the spring sheds in forested areas.

2. Enhancing quality of moderately dense forest, open forests, and degraded forests: The aim of this strategy is to improve the health of these type of forests, improve the ecosystem services and enhance the Carbon sequestration potential.

Actions for enhancing quality of forests would include- regulation and monitoring of invasive species and identification of non-native species that can survive climate change and be beneficial to the ecosystem, management of insects and other pathogens, Adoption of short rotation species, preventing forest fragmentation by conserving contiguous forest patches, Eco restoration of degraded open forests, and restoration of grass land.

Sustainable management of these forests would lead to increase in soil moisture content of the forests, increase in biomass density, along with increase in the flow of forest goods like NTFPs, fuel wood, hydrological services, improvement in biodiversity and enhancement in C sequestration.

Additionally trees in notified forest patches which are threatened by expanding urban/industrial development, Open spaces/green spaces like parks/wood lots set up on municipal land, Diffused planting such as on avenues and in households and Institutional lands, especially lands belonging to or allotted to business/industrial houses and educational institutions can be explored for enhancing C sequestration, as well as for improving the quality of soil, water and air of the immediate environment.

Schemes can be developed in the future, in which states having proven C sequestration potential in their forests, can sell the surplus to other states and earn C Credits.

3. Linking Protected areas: Aim of this strategy is secure corridors to facilitate species migration of both flora and fauna and adapt to climate change, especially for species with limited dispersal ability.

It can be done through connecting fragmented forests with 'Canopy Corridors' and 'Flyways' to assist species migration. Corridors will be prioritized and maintained by local stakeholders. As for people living in these corridor areas, rapid agency responses to crop-raiding, man-animal conflict, crop-insurance and hassle-free compensation would be some of the key interventions.

Special studies need to be launched to understand the feasibility of establishing such corridors and their effectiveness vis a vis natural dispersion and assisted migration in the context of climate change.

4. Mitigating impacts of land slides, storm surges and fast river run off- In northern hilly regions of West Bengal and the saline coastal areas, disasters in the form of land slides due to heavy rains and coastal erosion due to sea level rise and storm surges from cyclones are expected to rise in their intensity. Therefore affrorestation activities on slopes to strengthen the soil top and also planting of mangroves in degraded areas in the coast is necessary. Furthre, the hydropower dams planned along the Teesta in the northern hills are also at risk of receiving debris from Teesta run off as the temperatures increase and the discharge increases abruptly due to glacier melting and GLOFs.

5. Enhanced fire prevention and fire management: The strategy for fire managemnet can be two pronged, namely (i) early detection and management extended to higher altitudes, including community participation in management of fireand (ii) planting species in forests, immediately after the area is burnt with trees generated in the nurseries. Therefore nurseries have to be set up of Sal, Oak, and Conifer with adequate saplings available for future requirements. (iii) also considering that climate change is occurring, research needs to be carried out to identify forest tree species that would adapt itself at different altitudes.

6. Preventing man animal conflict: The aim of this strategy is to have sustainable forests that help wild life to thrive within the limits of the forests. Short term strategies could include Community initiatives, and identification Identification of conflict areas and periods, Extensive patrolling, Co-ordination with local community and administration etc can be taken up by the DEFWM. Medium term initiative could include capcity building. strengthening communication etc, senstization of policy makers etc. Long term strategies could be Population estimation of key species, study on agriculture practices, phenological studies of wild edibles.

7. Understanding long term impacts of climate change on forests and monitor health of forests and its C sequestration potential : . Monitoring the health of the forests and its biodiversity needs to be carried out in all forest types,. The aspects that will be monitored would include tree crown, tree growth, canopy structure etc.; ground vegetation, soil, forest floor and wood debris. This will also help to track the C sequestration potential of the forests.

8. Faster penetration of renewable energy technologies for energy: The aim of his strategy is to prevent forests from getting degraded due to over extraction of fuel wood and biomass for fodder and fire as the climate warms.

9. Protecting livelihoods dependent on forest products: Livelihoods of rural population living in the fringes of forests and depending on forest produce and other forest related activities may face decline in earnings as the forest degrade with climate change. Therefore livelihood protection is of utmost importance for these people. This can be achieved by enhanced forest-based biomass in the form of food, fuelwood, grass/fodder, timber, bamboo, cane and NTFPs. The augmented ecosystem services like water flows, biodiversity and carbon pools would further provide opportunity for augmenting incomes. Rich biodiverse and cultural landscapes could provide the potential to build up community-based eco tourism enterprises.

The strategies and actions there in are listed in Table 6 in Annexure 1.

8. Human Health

Introduction

The changing climate is affecting the basic requirements for maintaining health clean air and water, sufficient food and adequate shelter. Each year, about 1.2 million people die world wide from causes attributable to urban air pollution, 2.2 million from diarrhoea largely resulting from lack of access to clean water supply and sanitation, and from poor hygiene, 3.5 million from malnutrition and approximately 60,000 in natural disasters. A warmer and more variable climate threatens to lead to higher levels of some air pollutants, increase transmission of diseases through unclean water and through contaminated food, to compromise agricultural production in some of the least developed countries, and to increase the hazards of extreme weather.

Climate change also brings new challenges to the control of infectious diseases. Many of the major killers are highly climate sensitive as regards temperature and rainfall, including cholera and the diarrhoeal diseases, as well as diseases including malaria, dengue and other infections carried by vectors. In sum, climate change threatens to slow, halt or reverse the progress that the global public health community is now making against many of these disease.

Most of the diseases attributed to climate conditions are also influenced by the socio economic parametres driven by different developmental paradigms resulting in creating conducive environment for the occurrence and spread of the disease. Therefore, along with the interventions of the advancing medical science and pharmacology, though disease are being controlled, but the trends of the diseases over the years when seen in totality do not seem to be exclusively driven by climate. However, it is known that that with climate change some of the diseases may spread to newer areas and there might be emergence of new diseases as well.

Status of Disease profile related to climate in West Bengal

Water Borne Disease

Rise in temperature, rise in sea level, and erratic rainfall resulting in the floods and water contamination lead to various water borne diseases in various parts of the state.

Of the water borne diseases; Cholera, Acute Diarrhoea Disease (ADD), and Enteric fever are most prominently affected by the climate. These diseases are found at a quite high incidence in the state. Over the last three years 2008-2010, the incidence rate and the mortality rate of these diseases are found to be more or less constant. Among the different districts the annual incidence rate of Acute Diarrhoea in Dakshin Dinajpur, Cooch Behar and Malda is found around 50/lakh population with an indication of constant persistent of the disease in this region.

The incidence rate of enteric fever though less in comparison to the diarrhoeal disease but considering the large population the total number of cases seem to be a huge disease burden. The annual attack rate of last three years report of different district of the state shows that the disease is endemic in Bankura, Darjeeling, Malda, Purba Midnapore and Dakshin Dinajpur. Of these districts, the annual report of Darjeeling seems to be alarming as the attack rate seems to be increasing every year (3.5, 5.1, 7.5 in 2008-2009 and 2010 respectively.)

Table 8.1: Total cases and death due to diarrhoea and enteric fever reported in 2008-2010

Name of the Disease	Year 2008		Year 2009		Year 2010	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
Diarrhoea	2613147	600	2412158	541	1945148	244
Enteric Fever	136171	68	133242	91	146725	76

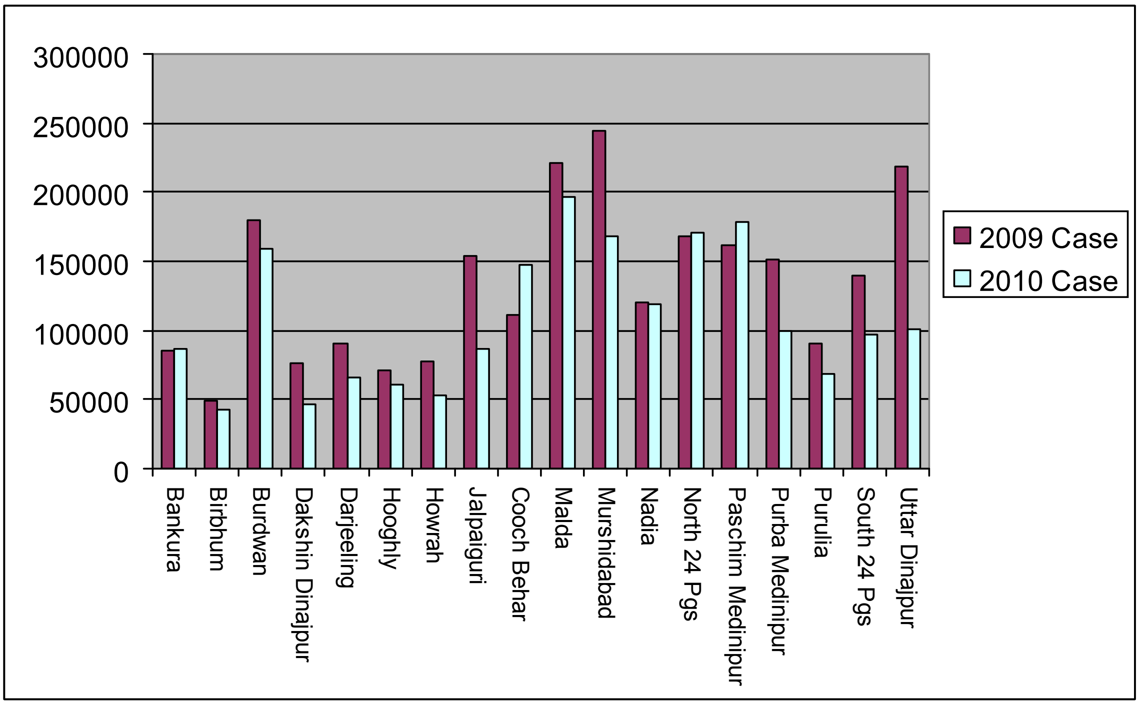


Figure 8. 1 : Incidence rate of Acute Diarrhoea Disease in districts of W.B in 2009-2010

Cholera

Cholera caused by *Vibrio cholerae* has a direct link with the climate fluctuation and can lead to not only local outbreak but world wide pandemic. The data available here only depicts the total number of cases and death report of a single research lab of the state over a span of three years. Though the whole scenario of the state is not available here but an idea of trend of the disease can be concluded as though the number of case and the death number of the disease seems to be decreasing but the existing number of the case in the last year is still high and Kolkata, North24 Parganas and South 24 Parganas seems to be a constant reservoir of the disease. In 2009 due to Aila super cyclone, an outbreak of many diseases happened, amongst which cholera was rampant. Therefore the positive rates in 2009 were very high when compared to other years.

In the year 2010, outbreak of cholera was observed in the three major districts of West Bengal. During the month of May 90 patients suffered from Cholera in the district of Howrah along with 3 deaths. In the month of June another outbreak was reported in the district of Nadia with 287 cases and in the month of October 24 cases were reported in the district of Jalpaiguri. So, the cholera outbreaks in these districts of West Bengal reports are total of 401 cases along with 3 deaths.

Table 8.2: Total number of case tested, confirmed and the positivity rate* reported from National Institute Of Cholera And Enteric Diseases (2008-2010)

Name of the	Year 2009			Year 2010		
	Total stool	No of	Positivity	Total stool	No of	Positivity
V. cholerae	1388	431	31.1	681	150	22.0
Shigellae	1388	65	4.7	681	52	7.6
Salmonella	1388	7	0.5	681	7	1.0

*Positivity Rate- (No of Confirmed cases x 100) / Total stool samples examined

Vector Borne Disease

Climate changes and increase climate variability, specially flooding present an increased risk of mosquito-borne disease epidemic. Increasing average temperature and greater variation in precipitation facilitate vector production and parasite transmission which could change the temporal and spatial distribution of the vector borne diseases. Studies between climate variability and malaria show that rainfall is an important indicator for early warning of malaria. Various studies reveal that the duration of sporogony in female *Anopheles* mosquito (responsible for the transmission of malaria), decreases with increase in temperature from 20^0 to 25^0 C which in turn accelerate the ovarian development, egg laying and frequency of feeding on host and thus the probability of transmission of disease

Among the vector borne diseases Malaria, Chikungunya, Dengue, Kalazar and Japanese Encephalitis remain a constant threat in our state. In addition to the mortality, the disease causes morbidity of millions of people resulting in loss of man days causing economic loss.

Table 8.3: Total case and death reported from 2008-2010 for vector borne diseases

	Year 2008		Year 2009		Year 2010	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
Malaria	89443	104	137768	74	139204	46
Dengue	1038	7	399	0	805	1
Chikungunya	593	0	338	0	231	0
Kalazar	1256	3	756	0	1482	4
Japanese	52	3	57	5	5	0

Malaria: Mainly *Plasmodium vivax* (Pv) and *Plasmodium falciparum* (Pf) are the pathogens responsible for the malaria in this state. The positivity rate of Pf % has been found to be more than 25% over the last three years and the Slide Positive Rate (SPR) remains 1.8 to 2.6 indicating a constant occurrence of the disease in this state. In West Bengal, Purulia, Jalpaiguri, Kolkata, Murshidabad, West Midnapore are the highly endemic zone of the disease. The malaria spread in West Bengal is shown in Figure 8.2.

However, total number of positive Malaria cases, total number of (Pf + Mix) cases and Slide Positivity Rate (SPR) in Kolkata is always been alarmingly very high as compare to the rest of the districts in West Bengal since last three years (2008-2010).

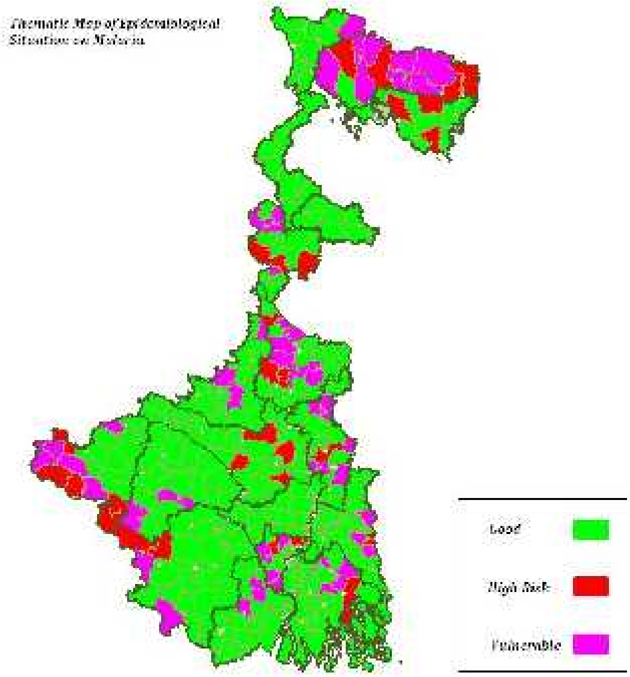


Figure 8.2: Recent endemic regions of Malaria in West Bengal

In the district of Nadia, North & Sought 24 Parganas, Dashing Dinajpur and Kolkata, the total numbers of Malaria positive cases are gradually increasing in last three years, while in the district of Purulia, Malda, Bankura, Cooch Behar and Darjeeling the total number of Malaria positive cases are gradually decreasing.

In the district of Nadia, Sought 24 Parganas, Hooghly and Dakshin Dinajpur, the total numbers of (Pf + Mix) cases are gradually increasing in last three years, while in the district of Purulia, Burdwan, Bankura and Cooch Behar, it is gradually decreasing.

Pf % only increasing in the District of Darjeeling in last three years, while Pf % is decreasing in the district of Nadia, Sought 24 Parganas, Howrah, Burdwan, Purulia, Bankura, Cooch Behar.

Slide Positivity Rate (SPR) is increasing in the district of Nadia, North & South 24 Parganas, Dakshin Dinajpur and Kolkata in last three years and SPR is gradually decreasing in the district of Purulia, Burdwan, Bankura, Malda, Uttar Dinajpur, Cooch Behar and Darjeeling.

Table 8.4: Total Malaria cases and percentage of Pf* in West Bengal from 2008-2010

Year	Total	Pf + Mix	Pf %	SPR
2008	89443	24453	27.34	2.00
2009	137768	37517	27.23	2.60
2010	139204	25190	18.10	2.54

* Pf%- (Pf+ Mix) x 100 / Total no of positive cases

Though number of incidences is increasing over the years, but a gradual decrease in the total number of death has been observed in most of the districts of West Bengal in the past three years including Nadia, South 24 Parganas, Murshidabad, Hooghly, Birbhum, West Midnapore, East Midnapore, Purulia, Bankura, Uttar Dinajpur and Kolkata. Although, sudden rise in the number of death, in the year of 2009 and again fall in the number of death was observed in the district of Malda, Cooch Behar, Jalpaiguri and Darjeeling.

Kala Azar: The blood feeding habit of the female sand fly, (the vector of Kalazar) increases resulting in the acceleration of the transmission of the disease with the rise in temperature. The endemic districts of the state for the disease are Darjeeling, Dakshin Dinajpur, Malda and Murshidabad reporting individually almost more than 200 cases with Malda being highest reporting 630 cases and 3 deaths in the last year. Spread of Kala azar across the state is shown in Figure 8.3.

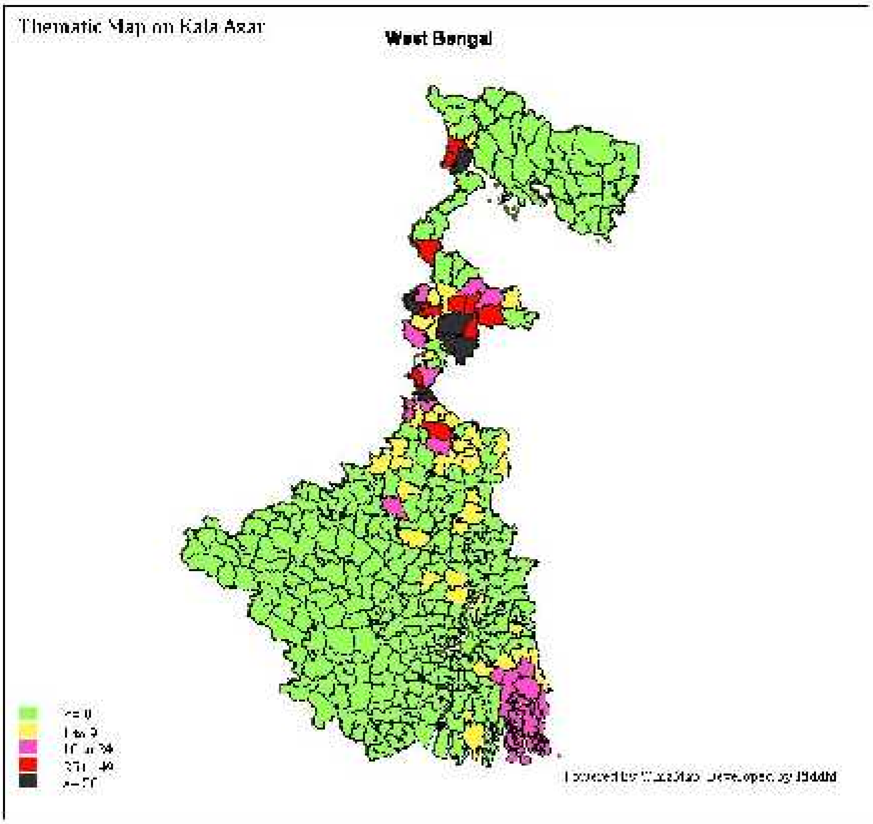


Figure 8.3: spread of Kalazar in West Bengal

Dengue: Both dengue virus development and female *Aedes aegypti* mosquito biting rates are sensitive to temperature and the potential risk rises to approximate 31-47 % due to an approximate 1^{0}C rise in temperature. Table 8.5 reveals that the case number over the last three years has decreased and the mortality rate is very low but the details district reports suggests that Kolkata, North 24 Parganas and South 24 Parganas still remain endemic with the number of case being more than 50 indicating urbanization may be an important parameter for the transmission as well as occurrence of the disease. Apart from these endemic zones a close monitoring of the district report over the last three years reveals that there is a sharp rise in the case number especially in the district of Bankura and Hooghly in 2010, when compared with the last two years. This may be a result of Global Warming. See Figure 8.4 for spread of Dengue in West Bengal.

Table 8.5: Sharp rise in dengue the case of two non-endemic district in West Bengal in 2008-2010

District	2008	2009	2010
Bankura	4	2	54
Hooghly	23	6	33

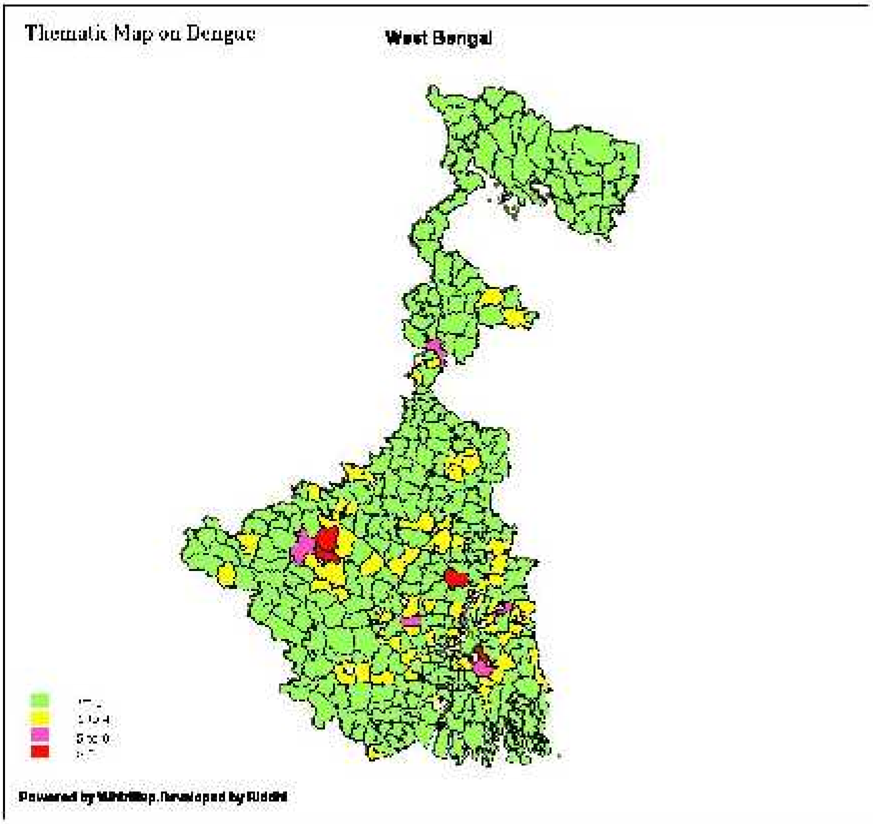


Figure 8.4: Spread of Dengue in West Bengal

Chikungunya: The out break of Chikungunya and the disease transmission mainly occurs due to the rise of temperature and irregular precipitation. Various surveillance reports also reveals that during drought the open house hold water container act as the ideal breeding place for *Aedes aegypti* mosquito, the vector responsible for the disease. Figure 8.5 shows the spread of Chikangunya in West Bengal.

There is a decreasing trend of the disease in the overall state no doubt but a close monitoring of the district report shows that North 24Parganas, South 24 Parganas and Kolkata remains a constant reservoir of the disease since last three years with a huge addition of the cases in Nadia and Burdwan and a reported disease outbreak of this region in the last year seems to be alarming as it indicates a very silent invading of the disease in the adjoining areas of the former districts.

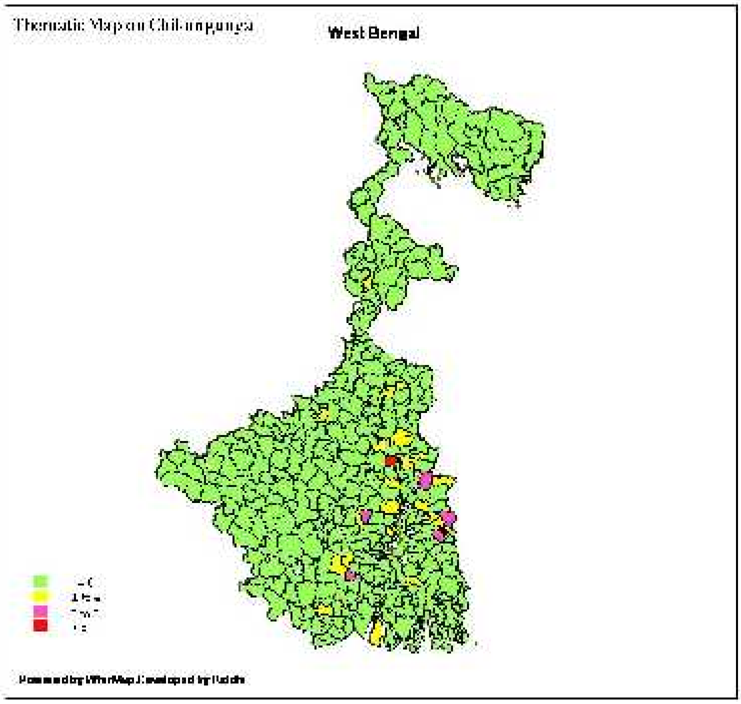


Figure 8.5: Spread of Chikanguniya in West Bengal

Japanese Encephalitis (JE)/AES: The disease Japanese Encephalitis (JE) caused by the female Culex mosquito has a direct link with the climate variation as it has been proposed that certain biotic and abiotic conditions favours the early seasonal amplification of virus and their transmission. The increase in temperature favours the development of mosquitoes as well as the viruses. In West Bengal, the number of Japanese Encephalitis cases were 52, 57 and 5 and death report were 3, 5, and 0 in the year 2008, 2009, and 2010 respectively.

Table 8.6: Positivity Rate* of JE/AES from 2008-2010

Year	No. of sample tested		JE/AES Positive		Death	Positivity (%)
	Serum	CSF	Serum	CSF		
2008	315	198	42	10	3	10.13
2009	454	259	41	16	5 (not serologically	7.99
2010	92	0	5	0	0	5.43

*Positivity Rate- (No of Confirmed cases x 100) / Total no of samples examined

Heat Stress

In tropical countries increase in number of duration of days of extreme temperatures causes heat stress leading to mortality. In this region, the the maximum and minimum temperatures are steadily rising, and the daily minimum temperature is rising faster than the daily maximum temperature resulting in gradual reduction of diurnal range. Span and intensity of winters is also decreasing. Winter temperature has increased by 0.4°C during the last 15 years ending in 2009 compared to the previous 15 years period and span of winter reduced by about a week during the same period.

The surveillance report of sun stroke in West Bengal of last two years shows that the total number of cases in 2009 and 2010 are 482 and 147 respectively with death reported to be 4 and 1 respectively. The most affected districts are Howrah (91 cases with 1 death), Nadia (44 cases), Paschim Midnapore (46 cases), Uttar Dinajpur (54 cases) and Birbhum (11 cases and 2 deaths) in 2009. However in 2010, the affected districts are Paschim Midnapore (53 cases), and Purulia (33 cases and 1 death). Paschim Midnapore remains the constant affected district with the number of cases increasing needs careful attention and monitoring.

Table 8.7 : Sun Stroke cases reported in 2009 & 2010 (Cases & Deaths)

Name Of the Disease	2009		2010	
	Case	Death	Case	Death
Sun Stroke	482	4	147	1

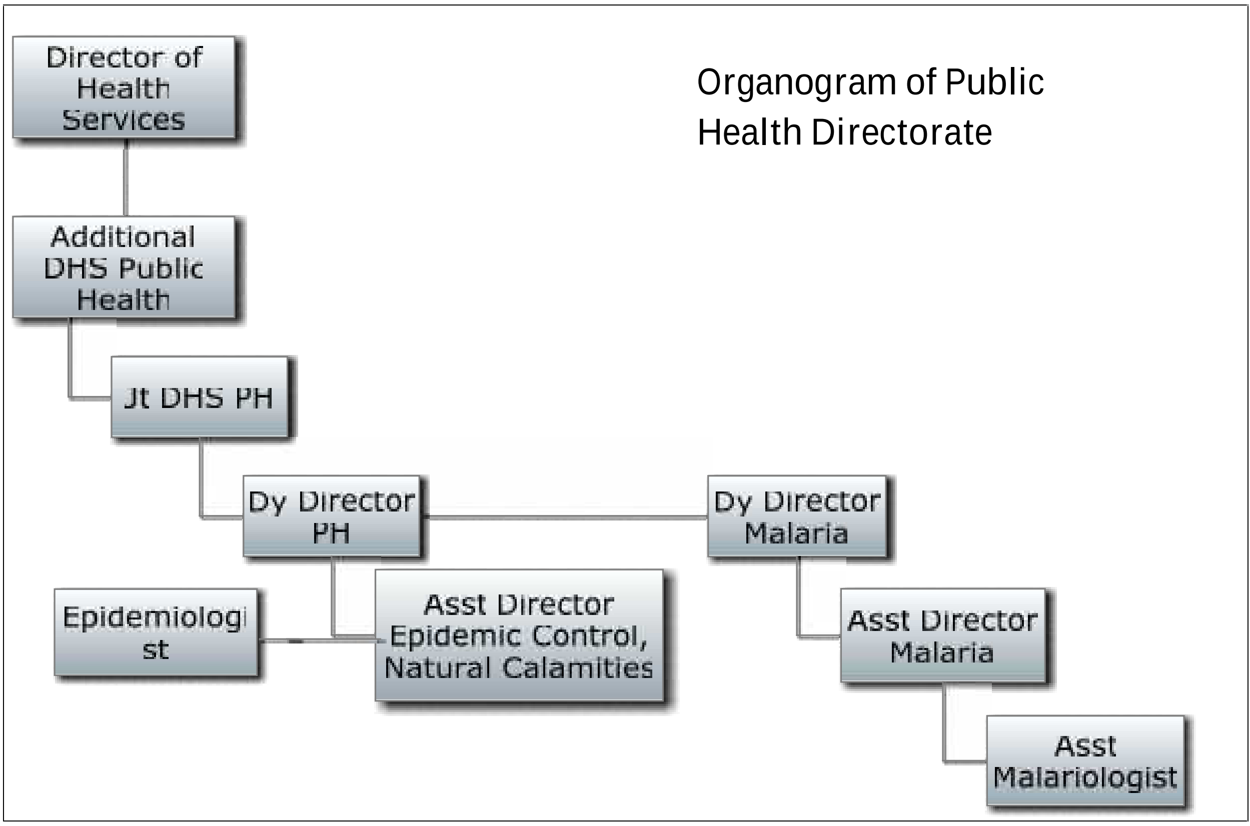
Policies and Programmes to Manage Morbidity and Mortality

Health and Family Welfare Department. Funding for some of the projects is received from the Central Government. The main programmes and projects that cover the climate related diseases, currently under implementation in the State are:

- National Vector Borne Disease Control Programme
- Integrated Disease Surveillance Programme
- State Water Borne Disease Control Programme
- State Disaster Management Programme

In the State at present there are 9 Medical College Hospitals, 16 District Hospitals, 46 Sub Divisional Hospitals, 35 State General Hospitals, 33 other hospitals, 93 Rural Hospitals, 253 Block Primary Hospitals, 921 Primary Health Centres and 10356 Sub Centres having total bed strength of 54,627.

The organogram for the Public Health Branch in the Health Directorate is shown in figure 8.6a. At the State level, the Coordination between the Urban Local Bodies and the Panchayati Raj Institutions are maintained by the State Health & Family Welfare Samiti. At the District level the Chief Medical Officer maintains the link with the urban local bodies and the Panchayati raj institutions.



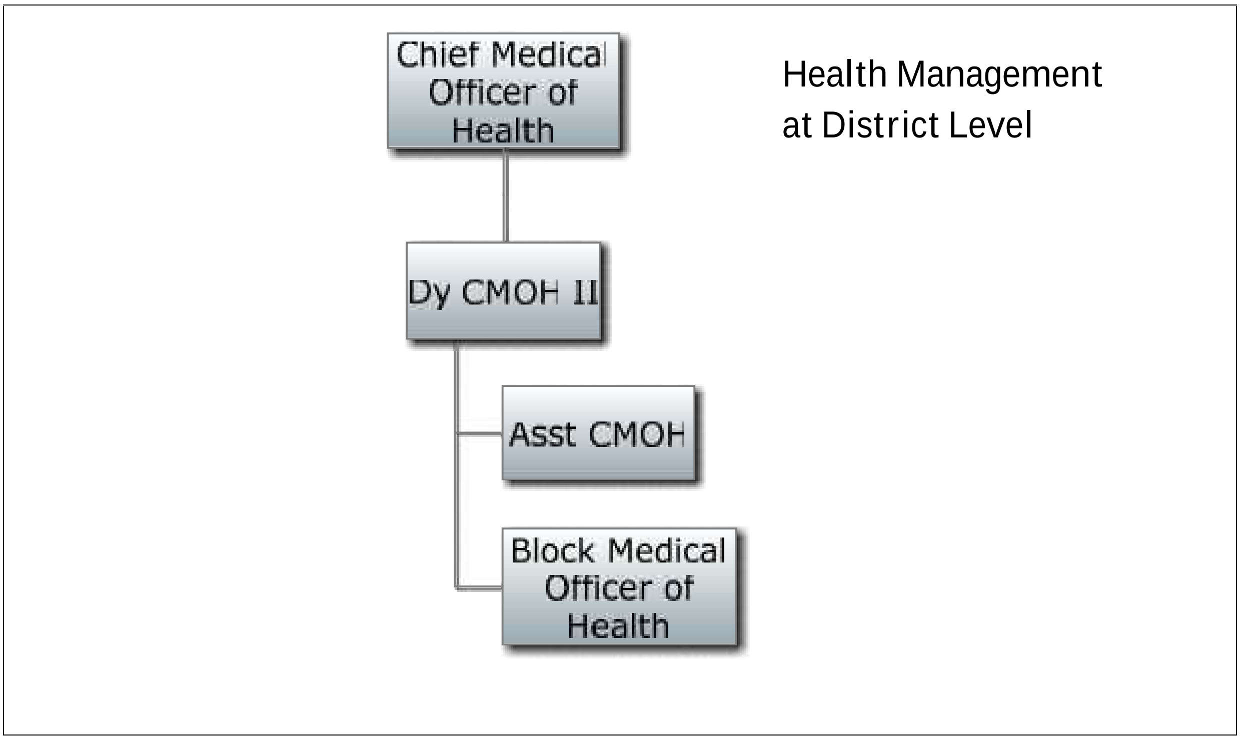


Figure 8.6: Institutional arrangement for management of health in West Bengal

Concerns related to Climate Change and Human Health in West Bengal

All populations will be affected by a changing climate, but the initial health risks vary greatly, depending on where and how people live. People living in coastal regions of Sundarbans, the megacity of Kolkata, and Hill zone, the Red and Laterite zone in West Bengal, and in the alluvial plains are all particularly vulnerable in different ways.

Impacts on vulnerable population: Health effects are expected to be more severe for elderly people and people with infirmities or pre-existing medical conditions. The groups who are likely to bear most of the resulting disease burden are children and the poor, especially women. The major diseases that are most sensitive to climate change – diarrhoea, vector-borne diseases like malaria,dengue, kalazar, chikenguniya (a new entrant into the scenario) and infections associated with under nutrition – are most serious in children living in poverty.

Newer areas of infiltration for vectors: Warming of the climate and the variable precipation across space, may offer newer sites of breeding of the vectors, pathogens, and bacteria. For example one study carried out to understand the likely spread of malaria in India (Bhattacharya et al., 2006) indicates that malaria may shift to higher altitudes.

Also it is noticed that vector borne diseases are becoming more and more endemic in cities, for example in the city of Kolkata, the total number of malaria incidences was 60% of the total malaria occurrence in the state in 2010. Clearly the endemic regions are the North Kolkata, around Calcutta medical college, around Kalighat, and in Garden reach.This is mostly because of the disturbance of the ecology of the region that naturally controls the pests and diseases arising out of rampant changes in land use, disturbing the draingae systems etc. Climate change indicating a temperature rise and likelyhood of occurrence of extreme precipitation events may lead to further retention of moisture in the ground and vegetation leading to more proliferation of all vector borne diseases.

Increase in incidences of morbidities due to increase in extreme heat events: Similarly an analysis of the occurrence of extreme temperatures (Sharma et al, 2001, private communications) using the outputs of PRECIS regional climate model driven by A1B scenario, indicates, that West Bengal is a state susceptible to very high temperatures and the number days that the extreme temperatures is likely to persist is increasing under this scenario in 2030s wrt to base line i.e 1960-1990.

Higher damages, morbidity and mortality due to increase in intensity of cyclones: Using a running average of high intensity cyclone frequencies in the northern Bay of Bengal area, scientists from Indian meteorological Department have observed a 26% rise in the frequency of high to very high intensity cyclones over the last 120 years. With rise in sea surface temperatures, the frequency and intensity of the cyclones likely to increase in the future, causing more morbidities and deaths, in addition to damages to property.

Increase in water borne diseases: Recurrent flooding in flood plains, and incursion of sea water on land due to cyclones, storm surges and sea level rise, is another concern for West Bengal. Though now much of it is not translated into disease, but with increase in sea surface temperature, algal bloom is likely to increase and may be carried over to land with sea level rise.

This then may be concern for increase in diaorrhea cases in the future in that region. This will be in addition to contamination of water due to increase in salinity. This can ofcourse be averted if safe piped drinking water is supplied to the community or the community is advised on safe measures to purify available water.

Increase in respiratory diseases due to increase in pollution loads as temperatures increase: Warmer and wetter climates are also detrimental to the population in cities as the levels of pollution go up. With increase in the road transport and other polluting sources in the cities, the warmer atmosphere may lead to more morbidity in the future affecting the productivity of the population. This is not only true for the city of Kolkata but will become a reality as urbanisation is increasing in the tier II and tier III cities of West Bengal.

Increase in morbidity/mortality due to increase in landslides: In the hilly regions of West Bengal, incidences of landslides are likely to increase with increase in intense precipitation as the climate warms. The hill people might be susceptible to such events, losing lives and property. Therefore, steps need to be taken not only to ameliorate the cause but also steps towards disaster preparedness and early warning from the health point of view is essential.

New and emerging diseases: Climate change combined with increased global mobility is resulting in previously unforeseen evolution of newly emerging infectious diseases worldwide and re-emergence of diseases previously under control and redistribution of diseases across the planet. Experts in climate change, climate policy, emerging infectious diseases and public health need to discuss the relevant and pressing issues that we as a global community face, and possible solutions that can be instituted.

Improved health conditions for all populations, alongside more rapid and effective disease surveillance, and systematic changes to address climate change while practicing agriculture, forestry and developing infrastructure, will constitute a vital contribution to the public health security in West Bengal.

Strategies and Actions

Climate change concerns have now been included as part of the State Health Policy. The other strategies that can strengthen the health policy vis a vis climate change can be as follwos:

- Strengthening the surveillance with an integrated approach for management of
  - vector borne diseases (in different agro meteorological zones)
  - water borne diseases (coastal and inland)
- Dealing with population displacements during extreme events
- Strengthening surveillance and management of Malnutrition and addressing food security issues along with the Social Welfare Department
- Strengthening disaster preparedness for Cyclones, floods and droughts including the management of psychological impacts
- Monitoring Air pollution and related respiratory tract diseases
- Initiating research to study the interplay of climate change and its impact on health
- Enhancing capacity of the institutions to address climate change related human health challenges
- Addressing Knowledge gaps

See Table 7, Annexure 1 for detailed strategies, actions, timelines and budgets for the health sector

9. Energy Efficiency and Renewable Energy

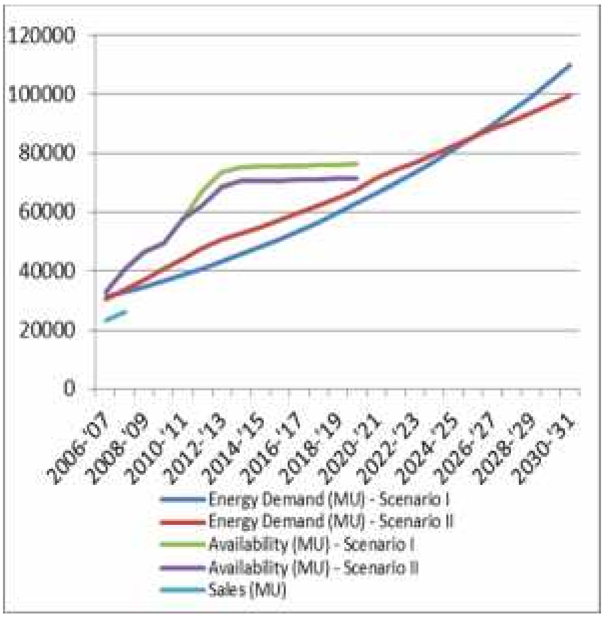
Introduction

The National Action Plan for Climate Change (NAPCC) emphasises the need for large scale investment of resources in infrastructure, technology and access to energy, towards attainment of India's development agenda which seeks eradication of poverty and improved standard of living. The NAPCC states that "In view of the large uncertainties regarding the spatial and temporal magnitude of climate change impacts, .the need is to identify and prioritise strategies that promote development goals while also serving specific climate change objectives." The strong positive correlation between energy use and human development is well recognised and a substantial increase in per capita energy consumption is anticipated while attaining an acceptable level of well-being amongst the citizens.

This section seeks to first set the context for the energy demand and supply situation in the state of West Bengal. It then focuses on the electricity sector, analyses the legal and institutional framework within which sector governance takes place and examines the roles of the key stakeholders. With this as background, a critical examination of GHG emission estimates is undertaken to identify and prioritise strategies that serve specific climate change objectives enunciated by the state.

Energy Use in the State

The primary fuel used in the residential sector in the state is predominantly biomass and fossil fuels. In rural West Bengal (NSSO[11], 2005), Firewood/Biomass is reported as the predominant fuel for cooking in 74% of the households, with dung cake (4%), LPG (4%) and the remaining using other fuel sources including coke/coal. Kerosene is the predominant fuel source for lighting reported by 65% of the households, with the remaining households mostly dependent on electricity. The urban scenario is markedly different with LPG (46%) being the predominant fuel for cooking, followed by coal (19%), biomass (13%) and Kerosene (11%). Electricity (87%) is the predominant fuel source for lighting in urban households followed by Kerosene. While data on the commercial sector is not available, one would assume that the trend follows a marginally progressive version of the residential sector for these end-uses. It is a ssumed that motive power in the commercial segment would be from petroleum-based fuels or electricity.



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[11] MoSPI. (2007). Energy Sources of Indian Households for Cooking and Lighting, 2004-05. NSS 61st Round (July 2004 - June 2005). National Sample Survey Organisation.

In West Bengal, 96% of the current electricity generation, is from coal-based generating stations, while the remaining is mostly from hydro-power sources with a miniscule share from solar. The state sector has an installed electricity generation capacity[12] of 10,398 MW (2010) and generated[13] 29,284 MU in FY 2010 through state and private generation stations. In Addition, the central sector generating stations generated an additional 17,363 MU in locations within the state. The absolute emissions from electricity generation in the state (CEA[14] 2011), amounted[15] to 53.14 Mt of CO_2 in FY 2009-'10.

The State level Perspective Power Planning Committee (2006) has projected[16] the aggregate demand for electricity to be between 66,368 and 71,351MU by FY 2021, based on scenarios[17] generated from economic trends, assuming a CAGR of 4% for the domestic segment, 6% for commercial and 3.5% for industry. The peak demand is projected to be between 8,937 and 10,871 MW in 2021 increasing to about 14,730 MW by 2031. In FY 2008, the state faced a shortfall in meeting energy demand (1188 MU) and also experienced peak-load deficits to the tune of 296 MW.

The state consumes (2010) about 5.5 Mt of petroleum products annually, of which Diesel (1.9 Mt) and Petrol (0.27 Mt) together account for 42% of the state consumption. The transport segment would be the end-use for most of this consumption. Kerosene and LPG together account for 26% of the annual consumption, with the predominant end-use likely to be cooking/lighting in the residential and commercial segments. Aviation accounts for 4% of the annual consumption, while Naphtha and Furnace Oil accounting for 18% of the annual consumption are likely to be consumed in the industrial and electricity generation segments.

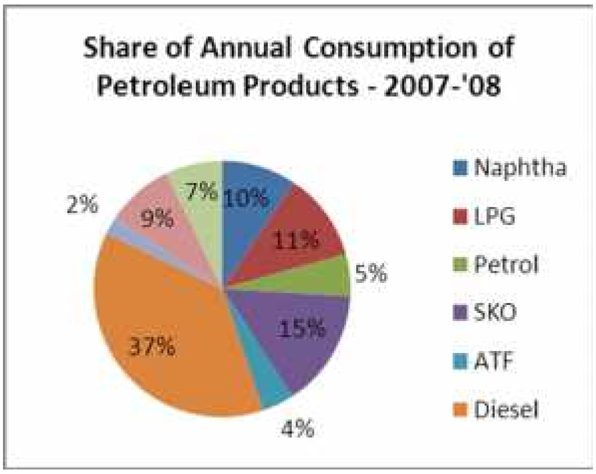

Figure 9.2: Petroleum Product Consumption in West Bengal, 2007-'08

The vehicle population (transport + non-transport) has witnessed a CAGR of 9% over the 1997-2006 period. With nearly 3 million vehicles operating in the state by the end of March 2006, two-wheelers account for 64% of the vehicle population and have witnessed a CAGR of 10%, while auto-rickshaws accounting for less than 2% of the vehicle population have experienced a CAGR of 11%. Four-wheeler passenger vehicles account for slightly less than 20% of the vehicle

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[12] Source: CEA Database, 2009

[13] Central Electricity Authority, 2011

[14] CEA. (2011). CO_2 Baseline Database, Ver. 6.0. Central Electricity Authority.

[15] Of this 35.11 Mt of CO_2 is directly from state and private sector generation, while 18.03 Mt of CO_2 is from central sector generation.

[16] The Committee had concluded that projection beyond 2019-'20 is of little significance as the technology development cannot be firmly envisaged.

[17] Scenario I assume a CAGR of 4.28% for Peak Energy based on analysis of data from FY 2000 to FY 2005, For Energy demand this scenario assumes a CAGR of 5.16% based on analysis over the same period. Scenario II has projections estimated from a 10 year trend of energy sale with adjustment for captive capacities.

population and have a CAGR of 7%. Buses account for only two percent of the vehicles registered, while good vehicles account for 8 percent.

Thus, the energy needs of the residential[18], commercial and industrial segments in the state are predominantly from fossil fuels and account for xxxx[19] Mt of CO_2 emissions) on an annual basis.

Electricity Supply, Consumption and Management

The Electricity sector underwent restructuring after the amendment in the national electricity Act (2003). The power development and supply arrangements are regulated by the West Bengal Electricity Regulatory Commission, which fixes tariffs and directs the generation, transmission and distribution utilities on the annual plans and quantum of power flows within their grid systems. The key generation, transmission and distribution entities are detailed in Table (9.1) below with a broad demarcation of roles, ownership and geographical coverage.

Table 9.1: Key Players in Electricity Generation, Distribution & Use, West Bengal

Entity	Sector	Roles	Particulars
Calcutta Electricity Supply Company (CESC)	Private	Generation & Distribution	Covers the city of Kolkata and suburban areas of Howrah, Hooghly, 24 - Parganas (N), 24 - Parganas (S) Districts
Disergarh Power Supply Company (DPSC)	Private	Generation	Sells power to WBSEDCL
West Bengal State Electricity Distribution Company Ltd. (WBSEDCL)	State	Distribution	Covers the whole of the state except the command area of other utilities, supplies bulk power to CESC
West Bengal Power Development Corp. Ltd. (WBPDCL)	State	Generation	Sells power to WBSEDCL and outside state, Manages Thermal Generation
Durgapur Projects Limited (DPL)	State	Generation and Distribution	390 MW installed capacity and supplies power to Durgapur city
National Thermal Power Corporation (NTPC)	Central	Generation	Manages generation through thermal stations in West Bengal and Hydro stations in Bhutan and Sikkim
Damodar Valley Corporation (DVC)	Central	Generation and Distribution	Manages multipurpose river project. DVC supplies power at HV in the districts of Bankura, Barddhaman, Howrah, Hooghly and Purulia and caters to the core sector consumers like

[18] A UNDP-ESMAP study (2001) found that in the households of rural West Bengal 87 per cent of total energy consumption is due to cooking, 5 per cent due to domestic lighting and the remaining 8 per cent is the share of water heating.
[19] This figure is to be taken form the GHG inventory data for the final version of the Action Plan.

Entity	Sector	Roles	Particulars
			Railways, Collieries, Steel.
West Bengal Renewable Energy Development Agency	State	Renewable Energy Generation and Use	Established in 1993 with the objective of promoting Renewable Energy Technologies
West Bengal Green Energy Development Corporation Ltd.	State	Renewable Energy Generation and Use	Created by Department of Power & NES, to promote different grid connected renewable energy based power projects through private sector and also to ensure investment of private sector in Renewable Energy system manufacturing.

Source: Compiled from organisation websites, Ministry of Power and NES, GoWB

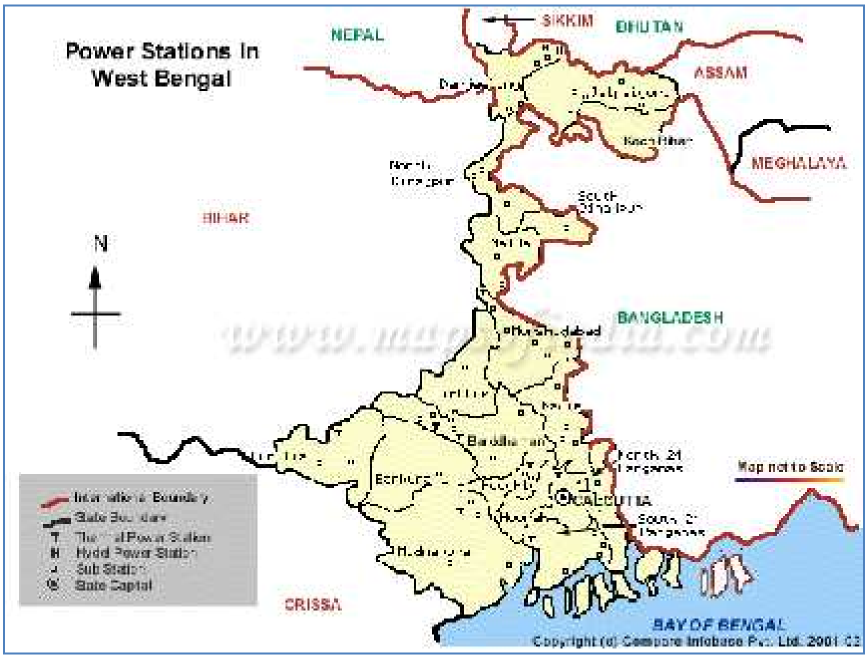

Figure 9.3: Power generation facilities in WEst Bengal

Electricity generation in the state is mostly coal-based (96%) at the Thermal Power Stations located in central and southern parts of the state (at the “chicken’s neck” in Murshidabad and around Kolkata in Barddhaman, Hooghly and South 24 Parganas), with some hydro-power being generated in Darjeeling district. The Perspective Plan for the Power sector (2006) had proposed coal-fired and gas-based power stations in Birbhum, Barddhaman, near Raniganj and

Bajora coal fields and near the industrial cluster of Haldia. An estimated 2,000 MW of captive power generation exists in the state. While some large ones operate on waste-heat, most are stand-by sets using petroleum products. Small captive sets (in the jute mills) are reportedly running on Furnace Oil. Intra-state transmission projects have been implemented over the 2007-2011 period with assistance from RIDF and PFC and new transmission lines for evacuating power from proposed generating stations are being executed under the eleventh plan. This is aimed at removing existing bottlenecks in evacuation of power from the southern part of the state and also in preparation of importing power to the eastern region grid.

In terms of consumption, Industries which account for nearly half of the state electricity consumption are located in clusters around Kolkata (Bantala, Dhankuni, Haldia, Falta), Kharagpur, Durgapur, Asansol (all towards the southern part) and Siliguri with upcoming centres at Chandmoni, Rajarhat and Haldia. The domestic household category which accounts for more than a quarter of the state's electricity consumption is spread across the state with markedly increased access in urban areas. Only 49 percent[20] of the rural households have access to electricity (March, 2009) and the concerted efforts in rural electrification under the RGGVY have been reported during 2009-'10. While results of this initiative are awaited, it is assumed that rural penetration could improve up to 75% by 2015. This would indicate about 3-4 million unconnected households, who could be using biomass[21] or kerosene for lighting and cooking. The commercial establishments account for 12 percent of the electricity consumption in the state. It is estimated that about 25,000 hotel rooms operate in the state (2007) with requirements for water heating[22]. It is projected that this requirement would be about 20 Ml annually by 2015, with possibly an equal demand from the clinics and hospitals segment.

The strategy for augmenting power generation in the state to meet anticipated and un-satisfied demand, drafted in 2006 anticipates a state sector dominated power industry in West Bengal. For augmenting electricity generation, Coal reserves in the Asansol-Durgapur-Purulia-Birbhum belt have been targeted, while gas sources are dependent on fructification of the Bangladesh pipeline or offshore discoveries under NELP II and III. The Coals-bed methane potential is significant and offers as better environment option. The untapped hydro-potential is highlighted, but availability of land and issues of displacement pose significant deterrent. Renewable sources offer options, with potential estimates as detailed in Table (9.2) below.

Table 9.2: Renewable Power Potential and Achievement in West Bengal

Energy Source	Potential (MW)	Cumulative Achievement (MW)
Wind (w/o offshore)	450	3
Biomass	350	80

[20] Source: Economic Review, 2009-'10

[21] There are about 0.2 million biogas plants installed in the state. An evaluation study by the Planning Commission had reported that 95% of the plants were in use (PC, 2002). However, it is also reported that the majority of the users are well-to-do farmers with adequate landholding. So most of the un-connected households are not expected to be biogas users.

[22] Greentech. (2010). Solar Water Heaters in India: Market Assessment Studies and Surveys for Different Sectors and Demand Segments. This report projects 52,022 hotel rooms requiring water heating by 2015. It also estimates about 50,000 hospital beds in the state requiring about 10,000 sq.m. of solar water heaters by 2013.

Table 9.2: Renewable Power Potential and Achievement in West Bengal

Energy Source	Potential (MW)	Cumulative Achievement (MW)
Small Hydro	300	100
Solar Photovoltaic	16,000	11
Solar Thermal	400	
Solar Roof-top	300	
Urban & Industrial Waste	150	0
All Sources	17,950	194

Source: Draft Renewable Energy Policy - West Bengal (PWC, 2010) and WBREDA (2010)

The cumulative achievement (till December 2010) on the renewable front has been limited to small hydro-power and Biomass (Gasification and combustion systems). While performance on tapping solar energy seems rather slow, it gains significance in comparison with the progress nationally. Solar Thermal power generation does not work with diffused radiation, whereas solar PV works with moderately low solar radiation and diffused conditions. The solar photovoltaic route is felt suitable for the state, while only low temperature (up to 120 deg) solar thermal needs to be considered in the initial phase. While significant potential exists for renewable sources, geographic location, end-use function, technology diffusion and grid-parity pricing will be key determinants in technology penetration.

National Mission, Policy Environment and Risks

The Jawaharlal Nehru National Solar Mission (JNNSM) seeks to create policy conditions necessary to promote the diffusion of solar energy use all over the country. The existing incentives and support measures have been strengthened and made more effective.

The following are some of the fiscal and policy incentives *available n*ow for production and use of solar energy systems:

- 100% foreign direct investment allowed in manufacturing and power projects;
- Zero customs and excise duties on wafers, solar cells, modules and some raw materials, 5% customs and excise duty on other raw materials and components;
- Tax holiday for manufacturing units in backward and specified areas, and for power projects;
- 80% depreciation in the first year for capital investments on solar projects; and
- Support for R&D and technology validation projects.

The JNNSM seeks to be a game-changer by growing the photovoltaic market to a Giga-Watt annually and the solar thermal market from nothing to a Giga-Watt over a decade. This kind of growth is expected to stimulate investments in new manufacturing facilities, and also the demand for a variety of materials such as poly-Silicon, solar glass and encapsulates. However, the risks and uncertainties also need to be noted:

- The physical targets are staggering and the phasing envisages about 16,000 MW of solar power capacity to be installed in the last five years (capacity-addition of 60 MW every week);

- Scale up of manufacturing will be particularly difficult in the solar thermal area, where there is no base in the country yet and where there only a limited number of technology providers;Financial Mobilization is high - an estimated investment of Rs.250,000 Crore will have to be mobilized[23] over the next 12 years, with the last five years averaging Rs.37,500 Crore annually;
- Requirement of Land is a contentious issue – About 100,000 acres of land need to be acquired over the next decade. As this will be distributed over 10-12 states, there is need for state governments to facilitate acquisition and necessary clearances. It would also be worthwhile to examine other options like creation of multi-purpose infrastructure or providing energy incentives to land-owners for settling this issue amicably.
- Performance assessment of Mega-Watt scale plants perform in the Indian grid conditions which are quite different from conditions in Europe and USA. There is the risk of the solar plants being cut off from the grid owing to frequency fluctuations and unsteady grid operations. There is also the fact that solar radiation data in many locations is insufficient for making reliable assessments of likely generation in a year;
- The favourable policy environment envisaged in the National Solar Mission has to be sustained over the entire life of the mission. It is not clear how long the present arrangement based on a supportive feed-in tariff will continue beyond 2013;
- The achievement of grid-parity by 2022, which is a key goal of the mission, depends on the realization of volume production and lower costs of production of modules and other items of equipment. At the same time, the demand and deployment will increase substantially only if the costs come down to a significant extent. Innovative mechanisms will be needed to bridge this time horizon.

Energy Saving Potential in West Bengal

West Bengal consumed 27,821 MU in FY 2008 with Industrial consumers being the single largest category accounting for 47% of the annual energy consumption followed by Domestic category accounting for 25% and Commercial category with 11 percent. Public water works and sewage pumping consumed 2 percent of the annual energy sales, while agriculture accounted for 4 percent.The "Assessment of Energy Conservation Potential in West Bengal" carried out by the NPC in 2009 provides the following estimates of possible savings in energy consumption, as detailed in Table (9.3) below:

Table 9.3: Energy Saving Potential in West Bengal

User Category	Potential Saving (MU)	User Category Annual Consumption (MU) in 2007-'08
Agriculture (only for irrigation pump sets)	333	1,110
Commercial (115 Buildings considered)	67	3,044
Municipalities (Public Lighting)	35	255
Municipalities (Water works & sewage)	53	478
Domestic	1,400	6,985
SME Industries Clusters (Cold Storage, Rice Mill and Tea)	62	370

[23] assuming an average rate of Rs.12.5 Crore per MW

All Industries	903	12,844
Total	2,791	

Source: NPC, 2009

The Bureau of Energy Efficiency (BEE) 'Energy Star Rating and Labelling Program' for domestic appliances initiated as a voluntary program for appliance manufacturers in May 2006, has been guiding the consumers on energy efficiency aspects of several commonly used home appliances. Since 7th January 2010, energy star labelling of room air conditioners, frost free refrigerators, and tubular fluorescent lamps has been made mandatory by BEE. It is expected that more home appliances will be gradually come under the mandatory provision of the program. The ECO-III Project with USAID/APP funding, has established three Regional Energy Efficiency Centres (REECs) in India, including the one at Kolkata keeping in view the Energy Conservation Act, 2001 and programs of Bureau of Energy Efficiency.

Under the National Mission on Energy Efficiency, the state energy conservation Fund was initiated in 2010, with initial contributions from BEE. This is primarily targeted to conduct benchmark studies for establishing energy savings potential in SME and Buildings, to draft the waste heat recovery policies for 20 identified industry types, DPR preparation for energy conservation ESCOs and Municipal DSM. The State Development Agency has also entered into a tripartite agreement with private investor and BEE towards establishing the "Bachat Lamp Yojana" in September 2010, with storage of material and awareness campaign being the responsibility of the WBSEDCL, while the investor bears the cost of the installation and replacement. The SDA also carries out awareness programs for the public (TV, Print, Book Fair), school children, Industry (workshops through PCRA), training support for energy managers and auditors, energy audits. An LED village campaign has been initiated in North 24 Parganas, while LED conversion of street lighting in the KMC area has been initiated with 50:50 financing.

In West Bengal the electricity consumption in the domestic sector is about 30% of total electricity consumption in the state. To raise energy efficiency awareness of public at large, the West Bengal Renewable Energy Agency (WBRDEA) with support from West Bengal Government and USAID has established a 'Regional Energy Efficiency Centre (REEC) for Home Appliances' at Kolkata.

Impacts of Climate Change

The envisaged climate change could impact different components of the electricity sector as outlined in Table (9.4) below. The list is indicative (and needs further development) and is more to identify risk-mitigation measures in energy systems that would need to be planned along with other adaptation mechanisms enunciated in the strategy later in this section.

Table9.4: Climate Change and possible impacts on the Electricity Sector

Climate Change Indicators	Impacts on the Electricity Sector
Hydrological Variability (greater seasonal and year-to-year variability in precipitation, more frequent and prolonged extreme events like drought or heavy rainfall)	Variability in Hydropower generation
	Variability in water availability for Thermal Generation
	Biomass availability vulnerable to water cycle impacts affecting household energy security

Table9.4: Climate Change and possible impacts on the Electricity Sector

Climate Change Indicators	Impacts on the Electricity Sector
	Could impact renewable generation potential, especially solar
	Threat of damage to infrastructure from extreme events
Increased Temperature	Impacts Hydropower generation in summer months
	Increased requirements of water for cooling in Thermal generation
	Increased need of energy in household sector for cooling
	Could impact renewable generation potential, especially solar

Given the intergenerational character of energy planning decisions, the long life span of energy infrastructure 15-30 years for power plants and 30-40 years for transmission lines and the expected rise in energy demand, it is important to understand the potential vulnerabilities of energy services due to climate consequences. The formal knowledge base is still at an early stage of development (ESMA 2011), particularly for assets that are indirectly weather dependent (eg. Thermal power, transmission). Renewable energy plays a key role in future low carbon emission plans aimed at limiting global warming. However, its dependence on climate conditions makes it also susceptible to climate change.

Thus, the current electricity generation and demand scenario outlined above can be summarised as follows:

- Energy demand[24] is likely to increase by nearly 2.5 times by 2021 and 3.5 times by 2031. Peak demand is likely to increase by 1.5 times by 2031.
- The electricity generation sector within the state will continue to be a large contributor to GHG emissions, as per the plans outlined in the state perspective plan. However, opportunities exist to mitigate this moderately through:
  - Shift in fuel-mix for generation from coal/gas towards benign solar/wind
  - Bringing down energy demand through efficiency improvements in T&D and end-use
  - Bringing down peak demand through end-use behavioural change and technology
  - Increased generation efficiencies and emission controls
- The electricity sector will continue to be the backbone of economic growth and will need to be buffered from attendant risks emanating from climate change – hydrologic variability, extreme events and performance variations from change in ambient conditions.

Key Elements of Strategy

[24] According to the Planning commission, Primary energy supply will have to grow by 5.8% per year through 2031-'32 to support a growth rate of 9% annually. If these assumptions hold, the increased demand is likely to be on the higher side.

The key elements of a multi-pronged strategy for mitigation and adaptation are outlined below:

1. Plan for reduced CO2 emissions compared to BAU scenario
   I. Increase grid power generation from renewable – xx% of capacity addition 2012-2022
      i. Solar PV for large scale power (as it works in low and diffused solar radiation cases) in districts (e.g. Purulia, Bankura) where wasteland is available (or abandoned mine areas)
   II. Replace use of grid power for certain end-uses through low temperature solar thermal – e.g. water heating
2. Reduce anticipated energy and peak demand in the BAU scenario
   I. Demand-side Energy efficiency measures in identified consumer categories through
      i. Efficient-device penetration facilitated by financial, supply chain and market incentives
      ii. Adequate financial incentives for lowering specific consumption
      iii. State-led adoption for enabling critical volumes of devices and technologies in local market and breaking current cost barriers
   II. Supply-side energy efficiency measures
      i. Enabling lower system losses (technical and commercial)
      ii. Enabling improved efficiencies in energy production
3. Risk mitigation of anticipated impacts from Climate change through
   I. Improved risk assessment of supply infrastructure (including lifeline infrastructure) for likely scenarios of climate change
   II. Investment and implementation of infrastructure-strengthening initiatives to cope with extreme events

See Table 8 and 9 in Annexure 1, for details of adaptation and mitigation strategies, actions, timelines and costs.

Chapter 10: Towards Sustainable Habitats

Introduction

West Bengal is the fourth most populous state in India, with a population of 91.35[25] million residing in an area of 88,752 skm. The overall density of population (Census, 2011) is 1029 persons/skm., and the sex ratio is 947[26]. The child population (less than six years of age) makes up 11% of the total population. The state has added 11.17 million to its population over the 2001-2011 decade, an annual growth rate of 1.39 percent.

The state exhibits significant diversity in climatic conditions, being a geographic area extending from the snow-covered Himalayas in the north through the alluvial plains to the deltaic and coastal environs of the Bay of Bengal in the south. The ***Hill region***, which is warm-humid to hot-humid is mainly forest area intercepted by terraced land under cultivation with field and plantation crops. The soils of the steep hill slopes are shallow in depth with high potential for erosion, while the soils in the foothills have moderate depth with moderate potential for erosion. The ***Terai and Teesta Alluvial region*** is hot-humid and the soils are moderately deep to deep. About 20% of the land is prone to inundation and water logging. The ***Laterectic, red and gravely undulating region*** in the west, coincides with hot-moist sub-humidity and hot-dry sub-humidity. This region comprises most of the Gangetic plain, where lowland soils are rich in fertility and upland soils are generally deficient in nutrients and prone to erosion. The ***Coastal Alluvial region*** is moist sub-humid and the soils in this region are imperfectly drained with moderate to high salinity hazards. Due to the predominance of Magnesium, the soils become hard and dry and non-porous when wet, impeding drainage. The ***Gangetic Alluvial region*** is hot moist sub-humid, and comprises the non-saline alluvial region mostly to the north and eastern part of the river Ganga. Upland soils are light and aid recharge. Groundwater potential is high and aquifer is mostly unconfined. The ***Vindhya Alluvial region*** is hot moist sub-humid type and is centrally located. About 10% of the region is susceptible to flooding, caused by impeded drainage and river overflows. Water from three major river valley projects flow through this area. There is significant variation in rainfall patterns across regions of the state, as represented in Figure 5.1a in Chapter 5.

A significant part of the state is relatively backward economically, and also tends to be less advanced in terms of human development (WB HDR, 2004). These include large parts of the six northern districts (Darjeeling, Jalpaiguri, Koch Behar, Malda, Uttar Dinajpur and Dakshin Dinajpur), the three western districts (Purulia, Bankura and Birbhum) and the Sunderbans area of the two 24 Parganas districts in the south of the state.

Demography and Settlements

Rural West Bengal accounts for 96% of the geographical area and accommodates 72 per cent of the state population (Census, 2001) in 37,109 inhabited villages. More than half (54%) of the rural population reside in 17% of the villages with population greater than 2,500, while 30% of

[25] Provisional Population Totals, Census of India 2011
[26] Females per 1000 males

the rural population resides in 29% of the villages that have a population between 1,000 and 2,500. Urban West Bengal accounts for nearly four percent of the state's geographical area and accommodates 28 percent of the population. Amongst the urban centres, the skew is more evident with 84% of the urban population residing in 27 Class – I cities (with a population of more than 100,000). The scheduled caste population make up 27% of the rural population and 13% of the urban population, while scheduled tribes comprise seven per cent of the rural and a little more than one per cent of the urban population. Among the minorities, the Muslims account for about 25% of the total population in West Bengal. Thus, these three categories – SC, ST and Minorities – who are reportedly the three poorest social groups in rural West Bengal, together account for more than half the population of the state.

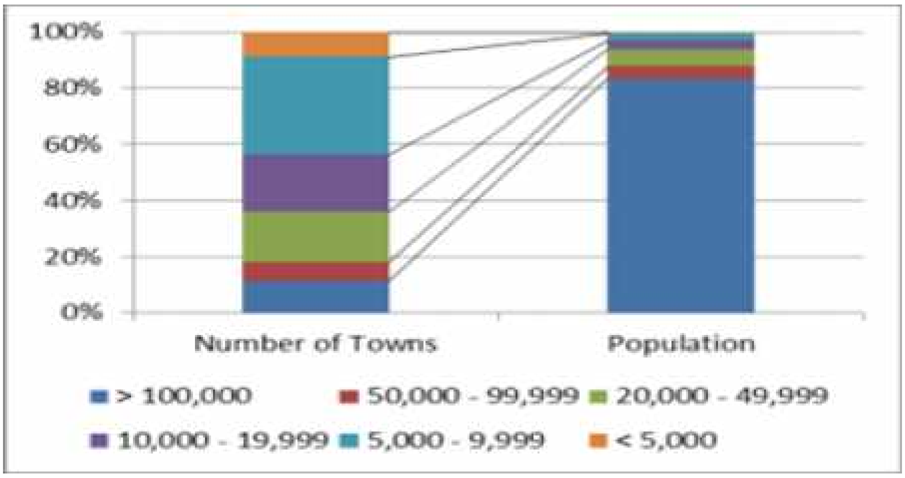

Figure 10.1: Distribution of Population by Size Class of Towns

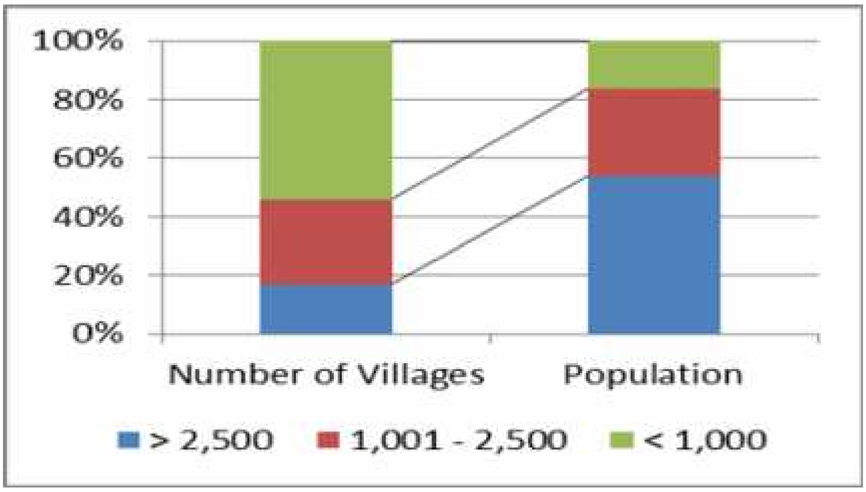

Figure 10.2: Distribution of Population by Size Class of Villages, 2001

A fundamental feature of West Bengal is the very high population density, which is nearly three times the national population density. Historical and socio-economic factors have determined the present very high density of population in the state. Apart from the internal migration from the neighbouring states to Calcutta, Haora and other industrial areas of the state, the Partition of 1947 led to an almost continuous stream of migrants into the State from across the Indo-Bangladesh borders. The phenomenal growth of population in some of the Northern districts such as Koch Behar and West Dinajpur and also in the Southern districts of Nadia and

24 Parganas during the period up to 1991 signifies the enormity of this migration. Subsequently, the districts with international borders have exhibited a decelerating population growth rate, while the non-border districts accounted for more than half of the decadal growth, indicating a spatial diffusion of population, when considered along with the moderate vital rates. With a population density of 1,029 persons (per skm.) in 2011, West Bengal is currently the most densely populated state in the country.

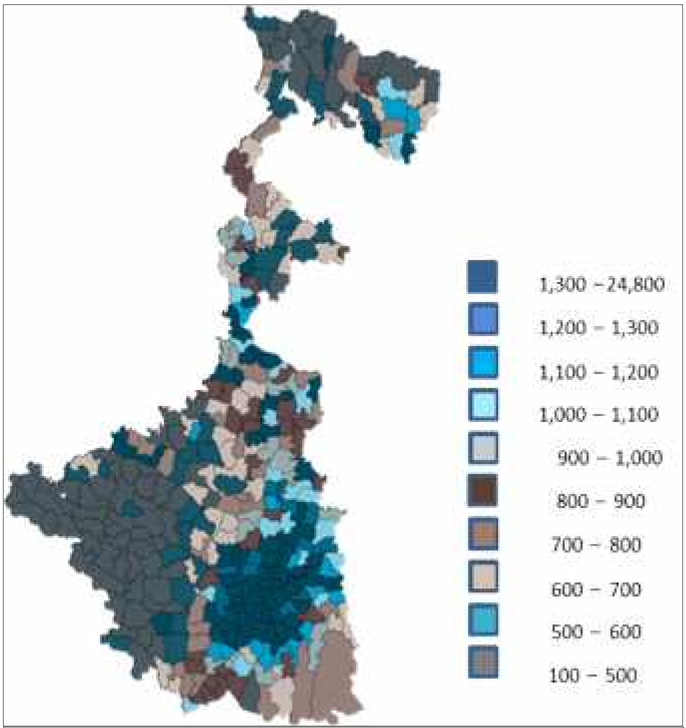

Figure 10.3: Population Density by C.D. Blocks - West Bengal (2001)

Source: West Bengal Human Development Report 2004

Nearly a quarter of the rural households and 2% of the urban households reside in kutcha houses, while 39% of the rural households and 8% of urban are reported resident in semi-pucca houses with the remaining 36% (rural) and 91% (urban) in pucca houses (NSSO, 2010). Fifty per cent of rural households and 93% of urban households had access to electricity (NSSO, 2010). Eighty-seven per cent of rural households and 88% of urban households had access to safe drinking water (Census, 2001), which was better than the national average. Seventy-three per cent of rural households and 15% of urban households did not have access to toilets (Census 2001), improving to 36% rural households without toilets and 10% without access in urban areas (NSSO, 2010).

Trends in Urbanisation

West Bengal is one of the highly urbanized States of India with 28 per cent of population residing in urban areas. In West Bengal the urban population grew from 10.97 million to 22.43 million during the 1971-2001 period but this huge population lives within four per cent of the total geographic area of the State which has resulted highest population density in the country of 6798 persons per sq. km. with the density for Kolkata Metropolitan Area (KMA) working out to around 8000 persons per sq. km.

The total urban population of West Bengal is spread across 127 Statutory Towns (Municipalities and Municipal Corporations) and 250 Census Towns (CT). While this amounts to nearly 28% of total state population, the statutory towns of West Bengal account for about 87% of the total urban population of the state, while the Census Towns house the remaining 13% (ASCI, 2011). There has been a gradual increase in the percentage of total state urban population living in CTs from 5.76% in 1971 to 12.72% in 2001. The compound annual growth rate of population living in CTs (5.35%) is more than twice the rate of the population living in statutory towns (2.35%) in West Bengal. Very high growth rate (greater than 5 per cent) of population in some specific Census Towns like *Chak Bansberia*, *Phulia*, *Khandra* and *Bankra* may be contributing to this trend

The process of urbanization in West Bengal also distinguishes itself from the general trend for the country as a whole. Small urban centres like census towns have emerged all over the State, increasing from 137 in 1991 to 253 in 2001. While the urbanisation rate in West Bengal is 28%, (just more than the national average), the state has also a higher percentage of main workers[27] within the tertiary sector - 44%, compared to the all-India average of 33%. Land area under non-agricultural uses is higher in West Bengal (19%) than in India (8%). The land-use data over 2003-2006 seem to indicate decrease in net sown area and corresponding increase in land for non-agriculture use. The trend is most discernible in Purulia, followed by Nadia and South 24 Parganas and then Barhaman, where non-agriculture land stock is emerging from barren and forest land too. Increased rural population densities are discernible in Uttar Dinajpur, Dakshin Dinajpur, Malda, Murshidabad, Nadia and Cooch Behar, pointing to a possible stress on urban infrastructure and services in these districts or good intra-district access or artisanal work (that allows working from home in connection with enterprise in urban area – e.g. piece work) that permits rural residence and urban work. The trend of growth of non-agricultural land, decrease in net sown area, increasing population densities, increasing share of industrial workers and traders, growth in road networks point to rural areas (and significantly the peri-urban areas) of the state acquiring urban character.

Kolkata is the second largest urban agglomeration with a population of 13.2 million as per 2001 census. The core area of Kolkata urban agglomeration such as Kolkata and Howrah Municipal Corporation areas show one of the lowest growth rates during 1991-2001 compared to the growth rates of 1981-1991. On the other hand, the peripheral area shows a reversal in the growth pattern in the decade 1991-2001 compared to the growth rates of core areas - the peripheral area registered three times growth in 1991-2001 compared to 1981-91.

While the spread of urbanization has positive impacts and created opportunities, it has also created many problems that act as barriers to improved quality of life. The cities are faced with problems of inequality, increased competition for basic needs and competition in access to essential services, socio-political and economic institutions and health threats. With increasing sprawl in the bigger cities and non-regulated peri-urban expansion in the smaller towns, it is expected that climate change and associated environmental stress will make the poor more vulnerable.

Given the spatial economic and social diversity in the regions and the state, urbanisation has served to highlight the stress on land and lifeline infrastructure in urban areas. While this has differentially affected the poor, the urban centres have also provided economic growth and opportunities to its citizenry. The urban sector in the sector contributes about 60% of the secondary and tertiary State Domestic Product (SDP). The urban areas are also the centres of institutional and cultural activities and provide health and educational facilities to the region. The spatial planning and development of the urban areas are therefore very important to ensure the growth of the activities in the urban areas and thereby providing the required boost to the economy of the hinterland as well as to the State.

The future growth in urban West Bengal is anticipated (ASCI, 2011) to be from a mixture of mineral-based mining and manufacturing activities and service sector growth in healthcare, IT and Financial services. The currently dispersed hubs of economic activity are expected to strengthen and exert influence on the existing core and neighbouring urban centres and also

[27] Economic Review, 2007-‘08

connected urban corridors, thus influencing urban growth in the associated districts. An interpretation of the anticipated urban growth influence from specific economic activities is presented in Table 10.1 below.

TABLE 10.1 Economic activity, Urban Growth, Drivers and growth influwnce districst/Area

ECONOMIC ACTIVITY	CITIES	DISTRICT	INFLUENCE AREA
Steel, Metals, Cement, Coal based thermal power, Mining and other Heavy Industries	Bardhaman, Asansol, Durgapur	Bardhaman	Birbhum and Bardhaman
Petro-chemicals, Chemicals	Haldia	Purba Mednipur	Paschim and Purba Mednipur,
Heavy Machinery, Automobiles, IT	Kharagpur, Mednipur	Paschim Mednipur	Purulia, Bankura
Food Parks, Agro-processing, textiles and Leather, foundry industry	Uluberia and Howrah	Howrah	Kolkata, Howrah, Hoogly
Jute mills and products, textiles, light engineering, paints and chemicals.	Hoogly Chinsura, Bhadreshwar, Rishra	Hooghly	
Tourism, Tea estates, Food and Agro, transportation based	Siliguri and Darjeeling	Darjeeling	Darjeeling, Jalpaiguri, Cooch Behar
IT, Health Infrastructure	Rajarhat, Bidhannagar	North 24 Parganas	24 Parganas North, 24 Parganas South
Finance and IT, Electronics, gems and jewellery, Export and Import trade.	Kolkata	Kolkata	All surrounding Districts

Source: Adapted from ASCI (2011)

Urban Projections and Structure of Urban West Bengal

The Technical Group on Population Projections constituted by the National Commission on Population (May, 2006) estimated that West Bengal would have a total population of 97 Million by 2021 and would cross 100 Million by 2026. It has projected the urban population to grow up to 29% (28 Million) by 2021 and reach 35 Million by 2026. The projected rural and urban populations are presented in Figure (5) alongside. A more recent estimate cited in the West Bengal Draft Urban Strategy document (ASCI, 2011) indicates an urban population of 34 Million by 2021 and about 52 Million by 2031. This growth rate, would however, depend upon the review of the state criteria of constituting municipalities (or statutory Urban Local Bodies) so that a much larger proportion of Census Towns will be managed by ULBs. It is felt likely that by 2031 the number of Census Urban Centres may be doubled and a larger percentage of them may be Urban Local Bodies (ULBs). Following the population projections enumerated in the draft urban strategy, and in anticipation of a more liberal statutory town classification schema in the state, it is anticipated that the structure of urban West Bengal would significantly change over the next 20 years. It is anticipated that there would be 13 Million-plus cities in the state by 2031 of 90 Class-I towns projected. The projection and ensuing urban structure is presented in Figure (4). While these projections are statistical models and rely mainly on vital demographic rates, there are also regulatory and infrastructural limits on growth in our cities. Indian cities have amongst the lowest Floor Area Ratios (FAR), ranging[28] from 1-3. In contrast, FSI in most Asian cities varies from 5 to 15 and in many Western cities goes up to even 25. However, such vertical expansion would also require investments in the appropriate enabling services infrastructure. Restrictive Floor Area Ratios (FAR) are termed as one of the significant impediments[29] to unlocking the reported potential of urban housing market in India.

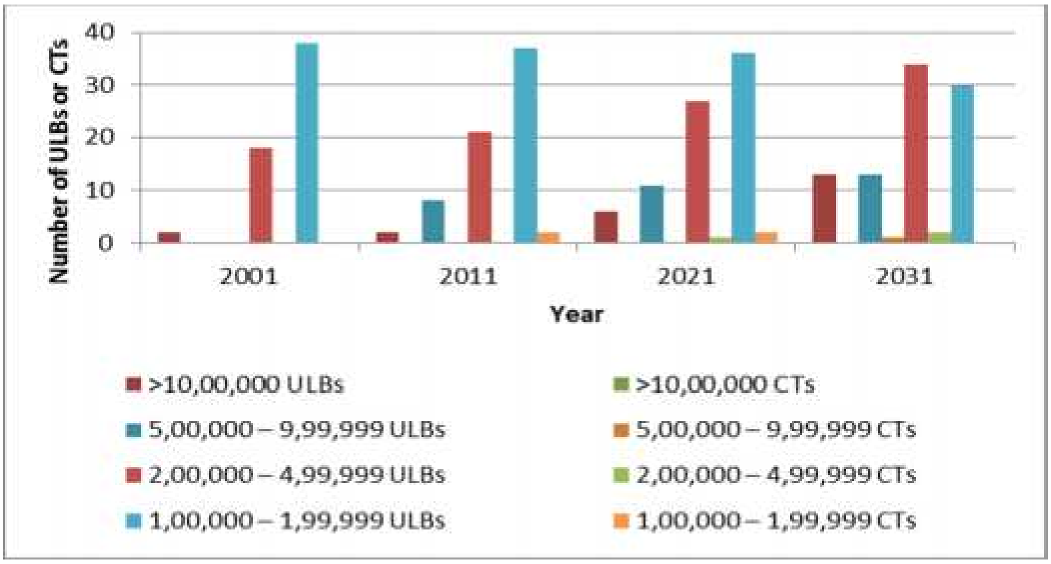

Figure 10.4: Projected Size Class of Urban Centres (2011-2031)

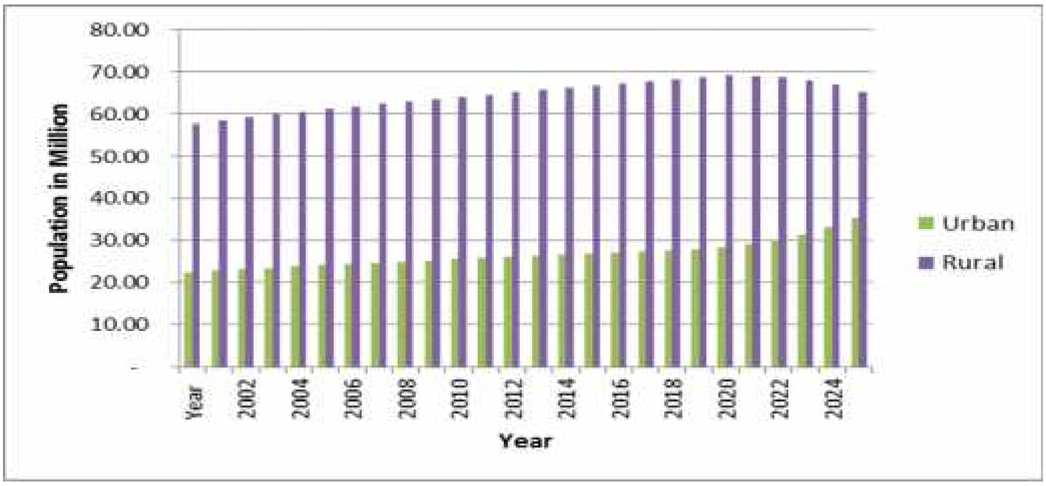

Figure 10.5: Projected Rural and Urban Population in West Bengal (2001-2026)

Source: Registrar General & Census Commissioner, 2006Figure 9.1: Projected Energy Demand, Availability (2007-2031) and Sales

Life-line Infrastructure in Rural and Urban Environs

[28] In Calcutta, the floor space index (FSI), or FAR, has been low, between 1 and 1.5 in most areas. Only in certain locations has the index, calculated on the width of the access road to the plot being developed, gone up to 2.5.

[29] Among all the bigger economies, India has the lowest FAR, which restricts the amount of built-up area that can be constructed on a land.

Water Supply[30]

The average annual rainfall in West Bengal is estimated as 1,762 mm. There is high variation across the districts of the state. Seventy-six per cent of the annual rainfall occurs during the four monsoon months and it is estimated that 21% water generated thus infiltrates through the soil, while 49% goes back to the atmosphere through evapotranspiration. While rainfall generates about 69.78 Billion Cubic Meters (BCM) of water resource, evapotranspiration exceeds rainfall during lean months when deficit amounts to 18.76 BCM. Thus net annual water resource generated from rainfall is 51.02 BCM and replenishable ground water resource is estimated at 34.20 BCM. The state receives 598.56 BCM of trans-boundary water from neighbouring states, 82% of this flowing through the monsoon months. There is high variation across districts in the resource availability.

TABLE 10.2: SECTORAL DEMAND FOR WATER IN WEST BENGAL (IN BCM)

Sector	Water Demand (in BCM)					
	2001	2011	2021	2031	2041	2051
Drinking Water	**0.088**	**0.099**	**0.110**	**0.119**	**0.126**	**0.131**
Rural	0.063	0.069	0.075	0.079	0.082	0.083
Urban	0.025	0.030	0.035	0.040	0.044	0.047
Domestic	**1.981**	**2.271**	**2.567**	**2.830**	**3.044**	**3.215**
Rural	0.837	0.924	0.998	1.053	1.089	1.112
Urban	1.144	1.347	1.569	1.777	1.955	2.103
Agriculture	**76.411**	**84.607**	**92.802**	**100.997**	**109.192**	**117.388**
Monsoon	42.339	42.339	42.339	42.339	42.339	42.339
Non-Monsoon	34.073	42.268	50.463	58.658	66.854	75.049
Industry	**2.60**	**4.61**	**8.17**	**14.48**	**25.66**	**45.48**
Forest/Ecology	**20.704**					**61.510**
Energy	**3.60**	**8.30**	**18.90**	**43.20**	**98.60**	**225.10**
All Sectors	106.18					452.82
Source: WBPCB (2009)						

The consumptive demand for water in the major sectors is presented in Table 10.2 above. While the demand in 2001 itself surpasses the net annual rainfall, the gap has been supplemented by trans-boundary water and exploitation of groundwater. The demand is expected to grow unabated in a Business-As-Usual scenario with significant increased demand from the Industry and Energy sectors as also non-monsoon agriculture.

The NSSO survey on housing conditions and amenities (2008-2009) reveal that 90% of rural households and 28% of urban households rely on groundwater sources for drinking. Nearly one in every two households (46%) in urban West Bengal have to collect water from outside premises, while about one in every five rural households have to travel more than 200 meters to access drinking water. The SWID investigations report that groundwater in 81 blocks is contaminated with arsenic and 49 blocks by excess fluoride.

[30] Most of the information on water supply and demand have been taken from "Water Resource and its Quality in West Bengal" a report by the WBPCB (2009).

The status of urban water supply is stark. There is a wide variation noticed in per capita availability, ranging from as low as 10 litres per capita per day (lpcd) to as high as 225 lpcd. On an average, 20.9 per cent households are connected through household connections. The service level benchmarking exercise for urban centres, initiated by the state government indicates that the average hours of supply of water across all ULBs is 6-7 hours. The quantum of water supply in ULBs varies from 10 – 225 lpcd per day. Quality issues are reported in many places (significant traces of iron and arsenic). Current plans for urban water supply infrastructure estimate requirement of water supply to the tune of 5,587 MLD by 2031 with a gap of 4,474 MLD.

Sanitation and Wastewater

Household Sanitation: The decentralised governance system for rural West Bengal places emphasis on Panchayat Raj Institutions. West Bengal has 3,354 Gram Panchayats situated in 341 Panchayat Samitis within 19 Zilla Panchayats. The resident population was about 58 Million in 2001, comprising 11.2 Million households. Under the Total Sanitation Campaign, household sanitation provisions have improved in rural parts of the state with nearly 64% of households reporting access to household sanitation facilities. Of the 3,354 Gram Panchayats nearly a third (1,041) are Open-Defecation Free by November 2010, while 37 Panchayat Samitis have also achieved this status. There are significant differences in sanitation attainments across districts, with Darjeeling, Purulia, Uttar Dinajpur and Malda showing slow progress. Also, the current initiatives have depended on on-site sanitation treatment arrangements (most commonly the leach-pit system) which could pose environmental issues to groundwater quality in settlements of high density and dependence on groundwater sources for drinking water.

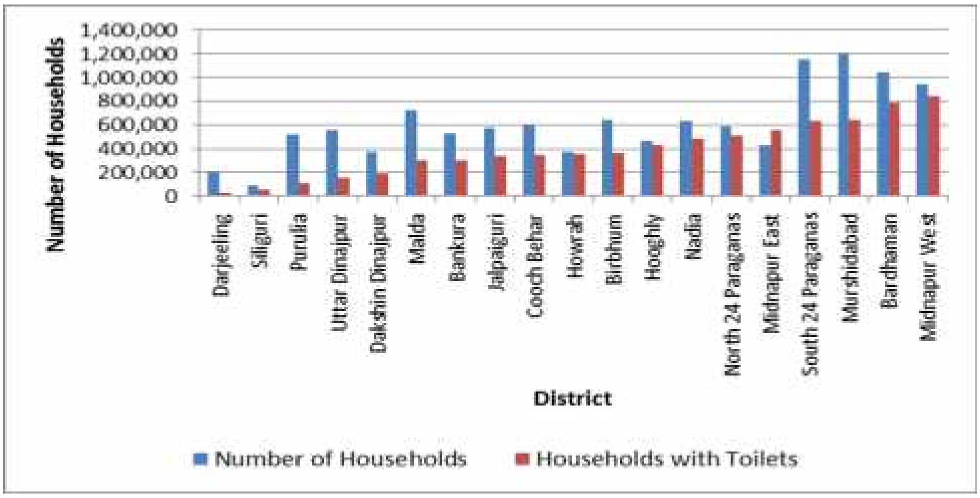

Figure 10.6: Current Status of Household Sanitation in West Bengal (2011)

Source: DDWS (2011)

The situation in urban areas is an improvement over the rural in terms of household access, but probably worse when one examines the full-cycle of collection-treatment-disposal required for safe sanitation and thus is short of any meaningful attainment for securing the health of the population. In urban systems, there is a mixture of on-site and off-site fecal waste treatment systems, with a few ULBs having set up Sewerage networks and Sewage treatment plants. Ninety per cent of urban households report access to sanitation facilities (NSSO, 2010).

According to an Urban Household Survey[31], 89% of urban households in the State have access to toilets. Of these, 78% have individual household toilets and others have access to shared/public/common facilities. Of the households having toilets, 22% have toilets connected to sewer, 56% households discharge to the septic tank, 15% households use the two-pit pour flush toilet, while two per cent households use Toilets without water closet and five per cent defecate openly. The survey also noted the non-existence of proper drainage network in almost all ULBs. Drainage pumping capacity was reportedly inadequate, with inadequate capacity of most drainage outfalls. Severe water-logging in congested city areas and low-lying areas during the monsoons was a reported regular feature.

Municipal wastewater generation in Class – I cities of the state is estimated[32] to be about 2,345 MLD, while sewage treatment capacities are only for 506 MLD (22% of wastewater generation). The lone metropolitan city, Kolkata generates about 706 MLD and has treatment capacities[33] of 172 MLD (24% of generation). Class – II towns generate about 180 MLD with treatment capacities existing for 34% (62 MLD). Under JNNURM and UIDSSMT, sewerage network and treatment plant capacities are to be enhanced in select urban centres. The City Sanitation Plans being prepared under the National Urban Sanitation Policy guidelines are also expected to aim for full-excreta-management in urban centres through a mix of awareness building, on-site and off-site sanitation arrangements and through building ULB capacities for regulating and managing sanitary waste, including solid waste. It is estimated that 75% of wastewater discharged into the Hooghly river comes from urban areas with industries contributing the rest. Management of wastewater assumes importance considering that one litre of waste water can pollute 5-8 litres of fresh water.

Solid Waste Management: Solid waste management is carried out at present primarily as a Municipal subject with the technical assistance and handholding support by Municipal Engineering Directorate for 85 non KMA and by KMDA for 42 KMA local bodies. As per directive from the Government of India, a specific fund has been earmarked out of 12th Financial Commission grant for all the local bodies for carrying out solid waste management in the proper and scientific manner with the objective of environment protection in accordance with current rules. Of the 126 ULBs, 95 have applied for authorisation to set up SWM systems in compliance of the MSW rules and 34 have been granted authorisation by the WBPCB. 81 ULBs have reported some system for collection of solid waste within their boundaries (ASCI, 2011).

West Bengal is estimated to generate about 27 Million TPDof solid waste with a collection efficiency of 70 per cent (CPCB, 2008). The service levels achieved by different ULBs vary significantly as detailed in Table 10.3 below. Various ULBs are in different stages of putting their SWM in action and performance has also been varied on ground. Segregation is reported in only 6 ULBs. Ten per cent of the waste collected in urban areas is reported to be treated and disposed in a scientific manner. Generally, Districts with good economic growth exhibit comparatively better services – districts in KMA – Kolkata, Howrah, Hoogly, North 24 Parganas and South 24 Parganas. Medium service levels are observed in medium-growth districts – Bardhwan, Birbhum, Darjeeling, Nadia and Murshidabad.

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[31] Conducted in 2006 and 2007 by the State Urban Development Agency (SUDA)
[32] CPCB (2009). Status of Water Supply, Wastewater Generation and Treatment in Class-I cities & Class-II Towns of India.
[33] The Eastern Kolkata wetland system should be treating an additional quantity of sewage, but the metro has a net deficit.

Table 10.3: Service Levels Reported by ULBs in Solid Waste Management

Service Level	Proportion of ULBs Reporting				
	Nil	Less than 30%	31-50%	51-80%	> 80%
Household Coverage	25%	32%	13%	17%	13%
Collection Efficiency	5%	9%	9%	17%	60%

Source: ASCI(2011)

Door to Door Collection System was introduced in 60% of the ULBs. It is currently operational in about 40% of the ULBs. Vermi-composting system for treatment of organic waste has been introduced in 8 ULBs. The sanitary landfill system has been introduced in 5 ULBs. A Plastic waste recycling plant set up in Rajpur-Sonarpur and an industrial waste treatment system at Haldia.

System of Common Treatment Facility has been set up in 5 Regions covering all the Urban local Bodies in the State . These are run on PPP mode by Private operators, who are responsible for collection of waste from the generation points directly at specified intervals. All the Hospitals, Nursing Homes, Clinical Laboratories and Health Care Institutes are covered under this program, are required to pay a specific user charge on the basis of their sanctioned bed strength to the agency directly for collection and safe disposal of their waste. Regional facilities are set up at ; Kona (Howrah), Haldia, Asansol, Kalyani and Siliguri.

Different types of Solid Waste Management Schemes are being taken up by KMDA within 40 ULBs. Under Sub-Mission-I of JNNURM, 2 projects – one at KMA covering 10 municipalities and another at Asansol has been taken up. The Asansol project seeks to introduce an efficient Solid Waste Management system in the Asansol-Durgapur Development Area consisting of Asansol Municipal Corporation (AMC), Durgapur Municipal Corporation (DMC) and Municipalities of Jamuria, Raniganj and Kulti. Another 6 municipal towns within KMA are being taken up under JBIC-ODA assistance. A project under the Italian Assistance for management of solid waste of 16 municipal towns has also been approved. The Municipal Engineering Directorate has also framed a few detailed project reports for the 22 municipalities outside KMA and Bidhan Nagar Municipality within KMA. A Solid Waste Management Mission has been set up under the Municipal Affairs Department. This mission has already been registered as a society and is meant to coordinate the entire programme of solid waste management. The Mission would also explore the possibility of organizing solid waste on a regional basis to ensure the economy of scale, as small projects tend to be non-viable. It will also strive to deal with the present day threats from the increasing complexity in the composition and characteristics of the waste and problems imposed by the new generation waste like E-waste and Bio-medical waste.

The current situation of Solid Waste Management is constrained by various issues. ULB face problems with non-availability of sites for disposal within their jurisdiction. Community participation and involvement has been lacking in SWM arena, symptomized by the non-segregation of waste at source and reports of households beset with the “Not-in-my-backyard” syndrome. Inadequate institutional capacities (in ULBs) to plan SWM, engage with households and to enforce rules, technology constraints (in operations) and market issues (for compost manure) pose challenges.

Travel and Transport

A noteworthy feature of West Bengal is that most urban settlements are located along established transport routes. Out of the total 127 ULBs and 252 Census Towns (CT) in the state, 51 ULBs and 101 CTs (40 per cent) are located within 5 km distance of National Highways. Similarly 100 ULBs and 169 CTs (71 per cent) are located within close proximity of existing railway networks. Additionally, the high population density in urban and rural areas should ideally make the region amenable to mass-public transport systems which prima facie might prove more economically viable in West Bengal compared to other states or regions. While too high a density causes problems of congestion and pollution, it is an advantage in infrastructure planning and setting up cost-effective transportation systems. More than one million people commute to Kolkata for work daily, mainly by local trains. This phenomenon imposes a great strain on the city's water, waste management and transport services infrastructure. Para-Transit, (also known as Intermediate Public Transit - IPT) mainly auto-rickshaws and also non-motorized rickshaws, play the intermediary role between public transport operating on trunk routes and interior localities. They provide service where it is required and at an affordable cost. Para transit is also one of the main sources of employment for low income groups in small and medium towns of West Bengal. A Government of India study computed the all-India average Slow Moving Vehicle Index at 0.065, where Kolkata figured at 0.035. Patna was the city with the slowest Moving Vehicle Index at 0.14.

A significant proportion of the freight traffic through the state is "transit" en-route to the north-eastern states or over land to Bangladesh. This poses a strain on the state transport and service infrastructure and also incurs a cost (in terms of time at border check-posts and clearances) for the transporter. It is generally believed that significant numbers of "aged fleet" ply in eastern Indian routes. Add to this the fact of Kolkata being a hub for movement by road, rail, sea and inland water (See Figure 8), the movement of cargo in different modes itself would pose a strain on existing infrastructure, unless one thinks otherwise and posits development as a transport hub. A careful review of the cargo movement situation would be in order to understand the costs to the state because of its geographical location, incremental costs of environmental pollution and GHG emissions arising, to work out economic methods of regulating/improving this facility with the view of maximising public welfare.

The state consumes (2010) about 5.5 Mt of petroleum products annually, of which Diesel (1.9 Mt) and Petrol (0.27 Mt) together account for 42% of the state consumption. The transport segment would be the end-use for most of this consumption. Kerosene and LPG together account for 26% of the annual consumption, with the predominant end-use likely to be cooking/lighting in the residential and commercial segments. Aviation accounts for 4% of the annual consumption, while Naphtha and Furnace Oil accounting for 18% of the annual consumption are likely to be consumed in the industrial and electricity generation segments.

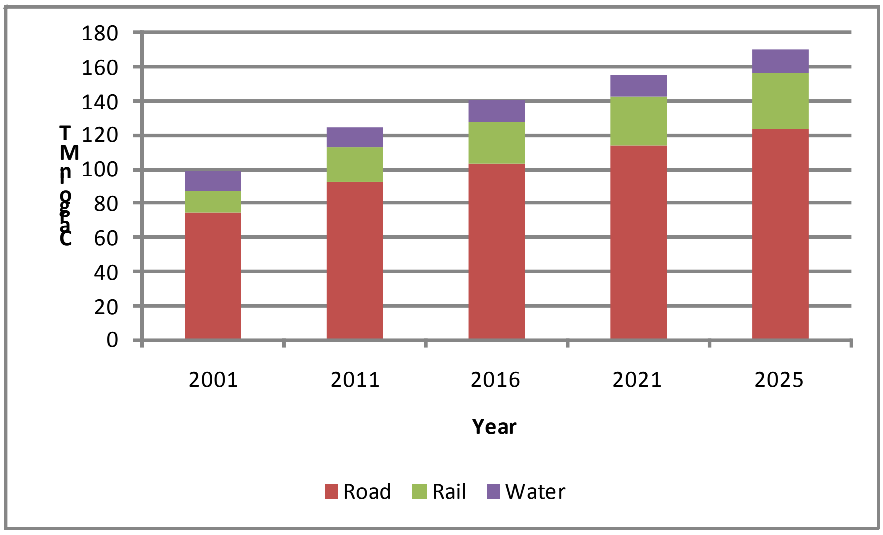


Figure 10.7: Estimated Cargo Movement To and From Kolkata

Source: KMDA (2006)

The vehicle population (transport + non-transport) has witnessed a CAGR of 9% over the 1997-2006 period. With nearly 3 million vehicles operating in the state by the end of March 2006, two-wheelers account for 64% of the vehicle population and have witnessed a CAGR of 10%, while auto-rickshaws accounting for less than 2% of the vehicle population have experienced a CAGR of 11%. Four-wheeler passenger vehicles account for slightly less than 20% of the vehicle population and have a CAGR of 7%. Buses account for only two per cent of the vehicles registered, while good vehicles account for 8 per cent.

Thus, the energy needs of the transport sector in the state are met predominantly from fossil fuels and account for xxxx[34] Mt of CO_2 emissions on an annual basis. Additionally, a significant proportion of rural household energy use (cooking being the end-use and accounting for 87% of household energy use in 2001) is met by fossil fuels.

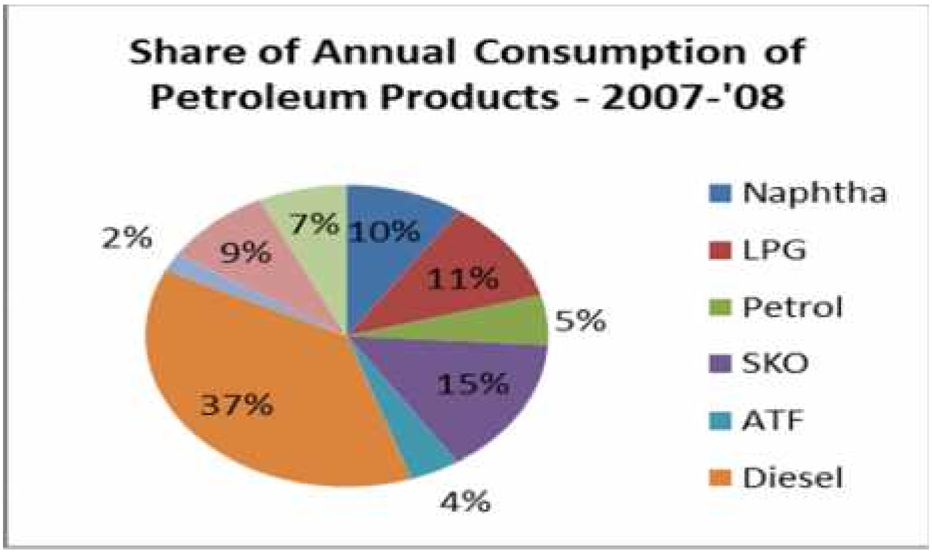


Figure 10.8: Petroleum Product Consumption in West Bengal, 2007-'08

[34] This figure is to be taken from the GHG inventory data for the final version of the Action Plan.

Housing and Construction

The housing sector in West Bengal is characterised by low access to drinking water, sanitation and electricity in rural areas and a significantly better situation in urban areas. It is also marked by a substantial proportion of biomass-based housing in rural areas. The details of households and access to amenities within premises are detailed in Table 10.4.

Rable 10.4: Housing and amenities in West Bengal

Amenity	West Bengal – Rural	West Bengal - Urban
Households Living in Pucca Houses	36%	91%
Households living in Semi-pucca Houses	39%	8%
Households Living in Kucha Houses	25%	2%
Households Living in structures with no drainage	83%	21%
Households with access to electricity	50%	93%
Households with access to electricity drinking water and sanitation within premises	16%	51%
Source: NSSO (2010)		

The West Bengal state government has enunciated a "Housing for All" policy. The target during 11th Plan Period is to construct 2 lakh dwelling units for the urban poor. Under the sub-missions of the JNNURM, all the statutory towns of the State have been covered under BSUP and IHSDP to provide housing for the urban poor urban. Additionally, the state government has taken up a separate scheme - *Housing of the Urban Poor* - since FY 2010 with its own budgetary support. Also, the Urban Development Authorities have constructed townships in all major urban centres. Within these, there is a mandatory reservation of economically weaker sections of the population. Of the 4.6 million urban households, 1.1 million belong to the poor (BPL). Nearly 50% of the poor households own their own house. An additional 2.4 households are earmarked for housing under central and state programs by 2012, leaving about 29% poor households without own houses.

Commercial Building construction is anticipated to grow at between 9-11 per cent y-o-y in the state. A substantial portion of this (at least half) is anticipated to be in the state sector constructed through the PWD, Housing Boards and Urban Development Authorities.

Table 10.5: Energy consumption within key segments of Habitats

Consumer Category	Energy Consumption in Million kiloWattHours					
	1991	2001	2006	2007	2008	Share of all Electricity
Commercial	1,096.12	1,910.51	2,528.65	2,786.32	3,043.94	12%
Public Lighting	70.89	146.02	232.46	241.34	254.66	1%
Public Water & Sewerage Pumping	242.13	365.09	448.04	467.92	477.90	2%
Traction (Railways)	550.46	771.40	939.45	981.81	1,042.71	4%
All Categories in State	8,821.47	15,472.74	21,401.17	23,462.08	26,230.90	
Source: WB Statistical Handbook, 2008						

While 12% of electricity consumption in the state (See Table 10.5) is accounted by the commercial category (most of it urban), Public Street Lighting accounts for one per cent, Water Supply and Sewerage Pumping (mostly Urban again) accounts for two per cent and the rail transport about four per cent. A sample survey of five government buildings by BEE in Kolkata had a covered area of 1.2 Million sft., with a connected load of 8,880 KVA and annual energy consumption of 16.6 MU (0.05% of commercial energy consumption in the state). It is reported that use of energy efficient devices could cut consumption by 15-20 per cent annually, and proper design (using environmental character) could bring down energy consumed by an equal volume additionally

Hazards and Vulnerablility

Cyclones and Heavy precipitation events: The East coast is packed right from the Coramandel coast up to the Mahanadi delta with disasters ascribed to Cyclones. The Sunderbans portion of North and South 24 Parganas districts has witnessed the highest frequency of events (see Figure (8)) followed by undivided Mednipur, Malda and then Kolkata and Nadia. Heavy rain disaster events reported, indicate an increasing frequency in the coastal districts, the southern and eastern districts, the chicken's neck area and the hilly region. The casualty from these events could be enhanced owing to landslides, in the hills and the large sea-dependent communities on the coast, and also the low-lying urban areas dominated by the poorer communities. The landslide hazard in West Bengal has been observed mostly in the hilly terrains of Darjeeling District. Urbanization, especially in the hilly terrains, involving construction activities often causes perturbations in the hill slopes triggering landslides (State Disaster Management Plan, 2009).

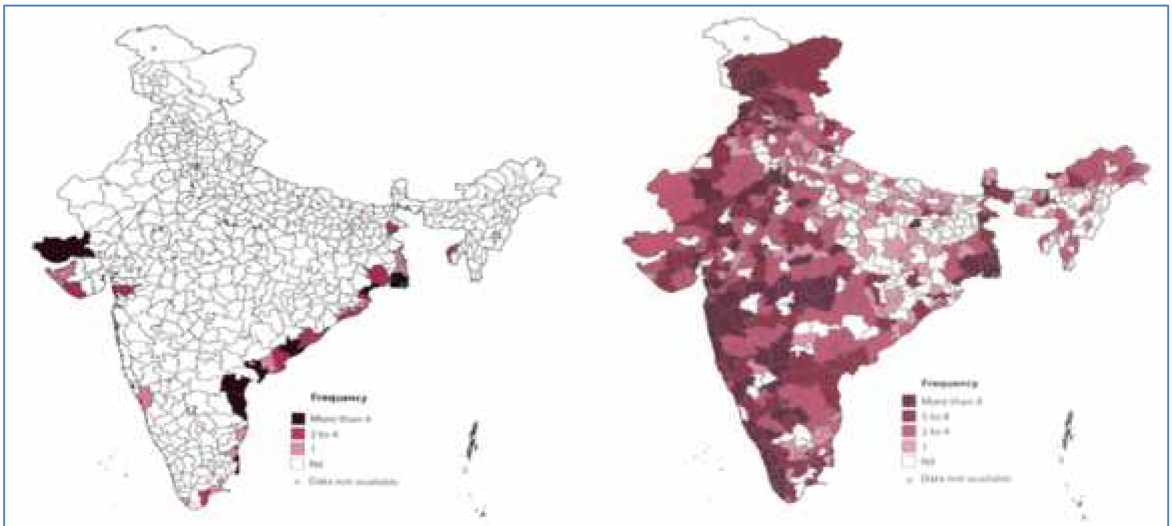


Figure 10.9: Occurrence of Cyclone (Left) and Heavy Rain Events (Right) – 1977 to 2002
Source: Kapur (2010)

Floods: West Bengal has about 56% of the region susceptible to floods. The vulnerability is made more complex by the origination of major flood-producing rivers beyond the state jurisdictional limits, viz, Teesta, Torsa, Joldhaka, Kaljani, etc. from Sikkim and Bhutan, which are mainly responsible for disastrous flash flood in North Bengal; also heavy rainfall in the catchment area of the river Ganga in Uttar Pradesh results in heavy onrush of water in the downstream of the Bhagirathi causing floods in its adjacent districts. The heavy rainfall in Western plateau [Ranchi] results in large inflow into the reservoirs of Maithon, Panchet, Messanjore etc. causes the necessary release of large volume of water from reservoirs. The heavy discharge from the DVC system and Mayurakshi system within a short span of time with onrush of water through the rivers causes inundation and water logging in vast areas. In addition, many of the rivers flowing through the State originate from northern Bangladesh causes flood in time of heavy rainfall. The IPCC identified Ganges-Brahmaputra as one of 4 particularly vulnerable deltas. The reported frequency of floods (see Figure (9)) seem to follow the river-courses in the state, thus impacting most of the regions – east, south, central, chicken's neck and the foot-hills. Flash flood occurrences have been reported highest in Mednipur followed by the districts along the coast, eastern boundary and the chicken's neck.

Heat Waves: Heat Waves are generally a series of winds laden with heat. These are typical of summer months of April and May and are characterised by hot sun over the long day with winds after the morning hours and occasional dust storm in the afternoon. These events account for 4 per cent of deaths from disasters in Inda and have been reported within West Bengal, with more frequency in the eastern districts, Mednipur, Purulia and the Chicken's neck area.

Other Hazards: Subsidence hazard has been exhibited in underground coal mining areas of the state, such as Raniganj and Asansol.

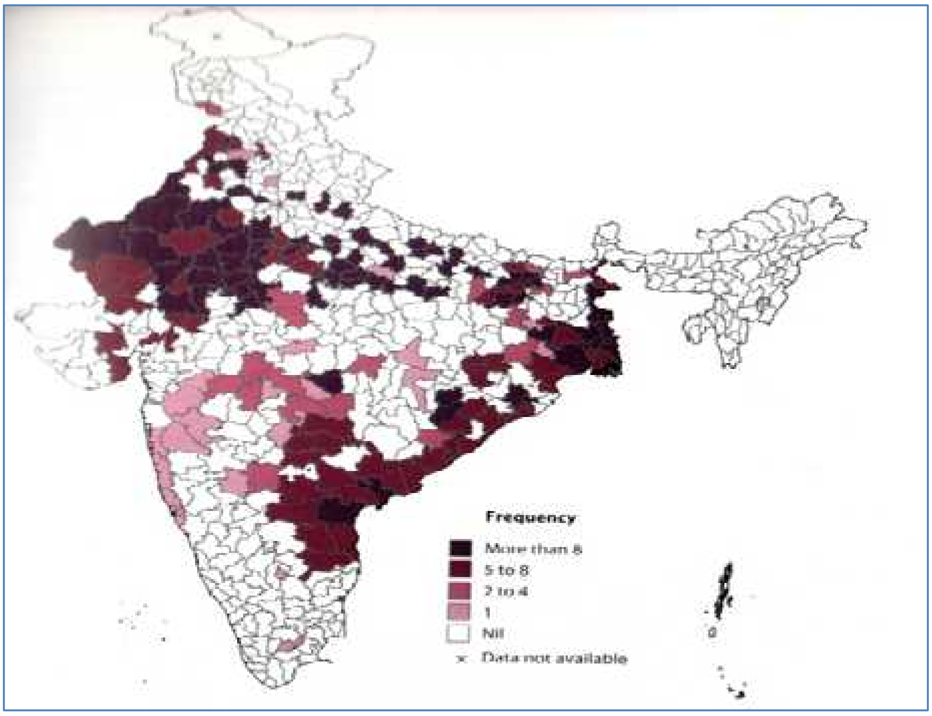


Figure 10.10: Occurrence of Heat Wave - 1977 to 2002
Source: Kapur (2010)

Governance and the Public Policy Framework

West Bengal has a history of progressive reforms in the area of governance signalling decentralisation initiatives even before the passing of the 73rd and 74th CA. The Panchayat Raj Institutions in rural areas and Urban Local Bodies in the urban, are designed to be the hub of participative and representative decision-making with the support and assistance of "line" departments staffed by professionals and experienced staffers. While the progress on decentralisation is an on-going process, the pace is probably faster in the rural domain, compared to the urban. Strategic planning and governance of climate change adaptation and mitigation initiatives for creating sustainable habitats would need to be situated in this decentralised governance framework with appropriate systems for technology assistance, capacity-building, data collection, monitoring and continuous evaluation, through an appropriate mix of regulatory authorities (like the Unified Transport Authority), professional agencies (like the Solid Waste Management Mission) coordinating and suitably enhancing the capacities of departmental staff serving the decentralised governance institutions, which need enabling towards becoming objective decision-makers with the longer-term interest of constituents in mind.

Likely Impacts of Climate Change

The many components of the Habitat system contribute towards GHG emissions and thus climate change. While mitigation options for identified GHG emission phenomena are identified in the specific sectoral strategies of this action plan, some cross-cutting mitigation initiatives will need to be managed within the habitat mission, owing to the nature of governance systems. Table 10.6 below summarises the various emissive phenomena within habitat and the direct and in-direct mitigation options.

Table 10.6: Sub sectors contributing to GHG emissios and mitigative potentials

Sub-sector	Potential GHG Emission	Remark
Transport	High (second highest emitter after electricity production, nationally)	Anticipated to be significant with the state serving as gateway to the N.E States
Construction and Buildings	Moderate; Growing sector with significant embedded energy consumption	Building management could lower energy consumption and hence electricity production need
Local Self Government Management	Moderate – emissions in wastewater and solid waste; Energy consumption in lighting and pumping	Public services like lighting, water supply pumping, sewerage pumping consume energy and currently not too efficiently

Source: IPCC, 2007

The envisaged climate change could impact different segments of the habitat as outlined in Table 10.7 below. The list is indicative (and needs further development) and is more to identify risk-mitigation measures in habitat systems that would need to be planned along with other adaptation mechanisms enunciated in the strategy later in this section.

Given the inter-linked nature of many constituents of the habitat system, it is important to continually monitor and seek to understand the potential vulnerabilities of different sub-sectors due to climatic consequences. The formal knowledge base is at a stage where we can identify starting blocks, but needs more data points and analysis along with real-time studies to confirm or disprove hypotheses and move our understanding forward.

Thus, the current habitat scenario outlined can be summarised as follows:

- Population is estimated to increase by nearly 20% by 2021 and 25% times by 2031. Urban concentrations will significantly increase accounting for 40% or more of the state population by 2031.
- The transport sector within the state will continue to be a significant contributor to GHG emissions, if one examines the transport need for a growing population. However, opportunities exist to mitigate this moderately through:
    - Shift in modal use from private transport to public transport
    - Bringing down fossil fuel use through efficiency improvements in transmission;
    - Bringing down net fossil fuel use by replacing significant share of current stock of para-transit (and non-motorized) vehicle modes with electric/solar powered vehicles for current;
    - Shift in city design and plan paradigm to provide public spaces, access to public spaces and comprehensive mobility (to reduced passenger kilometres) for different sections of population.
- The urban sector will be a major driver of economic growth and will need to be buffered from attendant risks emanating from climate change – hydrologic variability, extreme events and impacts from change in ambient conditions.
- The development priorities of state would require ensuring access to basic services – drinking water, sanitation, public health, sustenance food and work. Provision of adequate and safe drinking water would necessitate increased use of water resources, but would aid climate change mitigation initiatives by ensuring decreased flows of untreated wastewater into freshwater stocks, safe confinement and subsequent treatment and disposal of human excreta, safe and efficient collection of segregated solid waste, its treatment/disposal and energy recovery form solid and liquid waste to increase methane capture and substitute fossil fuel use.

Table 10.7: Climate change an dpossible impacts on Habitats

Climate Change Indicators	Impacts on the Habitat
Hydrological Variability (greater seasonal and year-to-year variability in precipitation, more frequent and prolonged extreme events like drought or heavy rainfall)	Variability in water availability esp. non-rainfall period for drinking and productive uses Increased vulnerability of population to heavy rains, floods, flash floods, Cyclone/Gale, drought, etc. Increased risk of damage to lifeline infrastructure from extreme events

Climate Change Indicators	Impacts on the Habitat
	More frequent instances of flooding and economic losses, esp. large urban centres Increased stress on lifeline infrastructure in urban settlements
Increased Temperature	Increased vulnerability of population to Heat waves Exacerbation of urban heat island effects Increased need of energy in household sector for cooling
Sea Level Rise	Increased vulnerability of coastal communities to floods, erosion and inundation Increased vulnerability to livelihoods of coastal zone resident, including macro-sectors like tourism Increased vulnerability of drinking water sources/supplies due to saline water intrusion

Adaptation Strategies

The key elements of a multi-pronged strategy for mitigation and adaptation are outlined below:

1, Plan for reduced CO2 emissions compared to BAU scenario

- Transport Sector through comprehensive planning, fuel economy standards, introduction of solar and electric rickshaws and auto-rickshaws;
- Methane capture in Wastewater and Solid Waste streams
- Reduction in electricity intensity to reduce emissions indirectly - Municipal Management (Water Pumping and Public Lighting being electricity-use segments);
- Reduction in electricity intensity to reduce emissions indirectly – Commercial energy consumptions (Public and large Private Buildings being electricity-hungry)

2.Increase system and citizen capabilities to adapt to temperature and rainfall changes anticipated Increased Warming, Changing Rainfall Intensity and temporal pattern and Extreme Events

3.Risk mitigation of anticipated impacts from Climate change through

- Improved risk assessment of lifeline infrastructure for likely scenarios of climate change

- Investment and implementation of infrastructure-strengthening initiatives and Warning systems to cope with extreme events

See Table 10 and 11 in Annexure 1 for strategies, actions, timelines and costs for the habitat sector.

11. Institute for Climate Change

Introduction

National Action Plan on Climate Change 2008 envisages setting up of an Institute in the State level – aiming towards formulation of strategic knowledge (encompassing climate change issues, energy security and food security) for sustainable development with economic growth of the state vis-à-vis country in eco-friendly manner.

Therefore it is imperative to understand the performance criteria what is really happening to environmental resources like air, water and forests in response to "geo-bio-cultural" interactions. Primarily, the institute will play a catalytic role in tracking research being conducted by different departments/ institutions/organization in the state and also undertaking its own.

Core-Business

Enrolment of partners and partnering institutions/organizations for building effective co-ordination; the Institute will act as a "Knowledge Domain" for "Transitional Research" i.e. to foster exchange of data related to climate change, good practices and policy initiatives across states of the country / adjacent countries with similar physiographic provinces e.g. Bangladesh, Pakistan, Sri Lanka and Myanmar.

A list of Partner Institutions / Organisations for each component groups has been prepared based on the discussion among sectoral committee members and GIZ representative and convener of the sectoral committee is indicated in Table 11.1.

Table 11.1: Partner Institutions

Sl. No.	Component Discipline	Govt. Deptt./Organisation/Academic Institution
1.	Atmospheric Science	Indian Meteorological Deptt., GoI Atmospheric Sc. Deptt., Calcutta University ISRO, Deptt. of Space, GoI CORAL, IIT, Kharagpur
2.	Land Use/ Land Cover & Soil Sciences	National Remote Sensing Centre (NRSC), Dept. of Space, GoI Deptt. of Science & Technology, Govt. of West Bengal Institute of Environmental Studies & Wetland Management Central Soil Research Inst. Bidhan Chandra Krishi Viswavidyalaya Uttar Banga Krishi Viswavidyalaya Viswabharati Pally Sikha Sadan
3.	Forest & Biodiversity	Forest Deptt., Govt. of West Bengal Biodiversity Board, Govt. of West Bengal Deptt. of Marine Science, Calcutta University Botanical Survey of India Zoological Survey of India

Sl. No.	Component Discipline	Govt. Deptt./Organisation/Academic Institution
		North Bengal University (Himalayan Study Unit)
4.	Water Resources	Irrigation & Waterways Deptt., Govt. of West Bengal Deptt. of Science & Technology, Govt. of West Bengal Central Inland Fisheries Research Institute Kolkata Port Trust Central Institute of Brackish Water Aquaculture Centre for Ground Water Studies State Water Investigation Directorate, Govt. of West Bengal Central Ground Water Board (Eastern Region) School of Water Resources, Jadavpur University Civil Engineering Deptt., IIT, Kharagpur, Fisheries Deptt., Govt. of West Bengal, Marine Science Deptt., Calcutta University
5.	Climate Change & Health	Public Health Engineering Deptt., Govt. of West Bengal School of Oceanographic Studies, Jadavpur University National Institute of Cholera and Enteric Disease Tropical Medicine Indian Institute of Chemical Biology CENTRO MAP Seth Sukhlal Karnani Memorial (Research Divn.) National Institute of Pharmaceutical Education and Research
6.	Livelihood & Adaptation	Global Change Programme, Jadavpur University Sunderban Biosphere Reserve Wing of Forest Deptt., Govt. of West Bengal Bidhan Chandra Krishi Viswavidyalaya World Wildlife Fund Deptt. of International Studies, Jadavpur University Agriculture Deptt., Govt. of West Bengal
7.	Energy Efficiency	Confederation of Indian Industries (State Unit) West Bengal State Electricity-Distribution Company Ltd. Power Deptt., Govt. of West Bengal Centre for Energy and Environmental Management Pollution Control Board
8.	Disaster Management	Disaster Management, Support Div.. National Remote Sensing Centre, Dept. of Space, GoI Deptt. of Science & Technology, Govt. of West Bengal National Disaster Management Authority National Institute of Disaster ManagementNational Institute of Disaster Management

Management of the Institute

1. The proposed institute should preferably be established under the aegis of Deptt. of Environment, Govt. of West Bengal as an autonomous body – could be managed through West Bengal Pollution Control Board (WBPCB). Government should provide adequate grants to the institute for its effective functioning. The name of the proposed institute may be "Institute for Climate Change Research & Ecological Design or Management".

   In this context, the "Institute of Environmental Studies & Wetland Management" (IESWM), a registered society under administrative control of Deptt. of Environment, GoWB may be considered to host the climate change institute initially. Subsequently, with necessary upgradation and expansion of the IESWM establishment, they may be re-designated as "Institute for Climate Change Research & Ecological Design or Management". This is being proposed considering the work module, available infrastructural set up and manpower strength (both scientific grade and administrative support staff) of the IESWM – pragmatic approach with S & T input to maintain space-time availability of the programme.

2. The institute will be advised and steered by a Science Advisory Council (Think Tank) – to be set up by the WBPCB/Environment Deptt., GoWB in due course.

   Advisory Council / Think Tank of the Institute would comprise of not more than 15 expert members:
   a) Chairman – Secretary, Deptt. of Environment, Govt. of West Bengal
   b) Expert members will be from Academic / R & D Institutions with National / International repute in component disciplines.
   c) Tenure of members of the Advisory Council will be 3 (three) years excluding the Departmental Officials.
   d) Advisory Council meeting may be convened on quarterly basis. However, a general review meeting may be organized on annual / biannual basis.

   Chief Environmental Officer, Deptt. of Environment, Govt. of West Bengal may act as Member Convener till establishment of the Institute.

Prime Activities

Goal

The proposed institution is to build research strengths, rethink current development models and to maintain a strong and effective co-ordination among the existing knowledge institutions in national and international level to address the climate change issues and challenges of the civil society. Under the various themes indicated in Table 11.1, the main objectives are as follows:

Objectives

- To develop techniques to translate climate change information (both climatological and model prediction) for useful applications by different stake holders e.g. research groups engaged in impact and vulnerability assessment or even end-users like farmers, fishermen etc.

- Training and capacity Building – Emphasis on skill development, at all levels, across various sector to enable communities become sufficiently empowered with know how and specific required skills, necessary for adaptation to CC.

A. Atmospheric Sciences:

- Study on Atmospheric composition, climate and variability – Monitoring, source identification of various Green House Gases (GHG). Aerosols, space-time variability, bio-geochemical aspects etc.

- To develop capacity to undertake climate change modeling

- To identify and explore new areas of research related to the fundamental understanding of earth's climate system and to undertake collaborative research with national/international level institute.

B. Landuse, Land Cover & soil Sciences

- Identification of Disturbance Gradient Zone in the bio-physical environment – Monitoring and assessment of landuse and land cover (LULC) changes, especially in the sensitive environment e.g. the Himalayan region, coastal zone etc.

- Geo-history modeling of natural hazards/disasters – dynamic viewing capabilities encompassing past-present-future Climate–Society interactions for identifying 'geo-environmental indicators' towards framing 'strategic guidelines' in societal perspective.

- Mapping Soil nutrient and characteristics across the state and understanding its interactions and role in the entire system

- Study on plant pathology and pest management in the context of "Pests, Diseases and Weeds" because of their importance as yield-reducing factors in agriculture and plant diseases functioning of ecosystems and the profitability of crop production

C. Biodiversity and Forests

- Prioritization of Bioprospecting Zones – Enhancing ecological sustainability to maintain/ conserve uniqueness of biodiversity – study of micro flora (including medicinal plant variety) and fauna, wild life and animal population in ecologically sensitive areas like the Himalayan region, mangrove swamp zone in coastal belt or land degradation areas.

- Studying the role of forests in ecosystems and supporting livelihoods, C sequestration potential of forests, and other forest related studies, and understanding the impacts of climate change on forests and associated vulnerabilities

- Generate scientific documents for informed decision making

- Undertake training programmes in various aspects of biodiversity and forests vis a vis climate change

D. Water Resources

- To study the impacts of Climate and climate change on –Hydrodynamic Circulation – 'agro-water-ecosystem' potential and vulnerability in response to any change in hydrological cycle, glacial retreat etc. – hydrological modeling of regional basins/ watersheds to 'locale specific' recharge issues on micro-watershed level.

- Undertake studies to understand the consequent socio economic impacts and hence tdevise strategies to adapt

- Generate scientific documents for informed decision making

- Undertake training programmes in various aspects of biodiversity and forests vis a vis climate change

E. Climate Change and Health

- To understand the interactions of climate with the human health in the West Bengal context, and the vulnerability of the population such as and not limited to
  - Heat stress related diseases
  - virus and vector epidemiology
  - Water borne diseases
  - Infectious diseases

F. Energy Efficiency

This sector intends to cover the following but not limited to

- Study the various energy efficiency options that can be implemented in the state of West Bengal, including the use of new and renewable energy,

- Provide Technology development and support,

- Undertake studies to identify base lines emissions and make emission projections

- Contribute to developing projects towards gaining C credits through various mechanisms both national as well as international such as PAT and CDM respectively

- Devise demand management programmes for more resilient and adaptable society.

G. Disaster management

- Understand the climate change implications on Hazard and vice a versa

- To develop adaptation plans for disaster risk reduction and mitigation

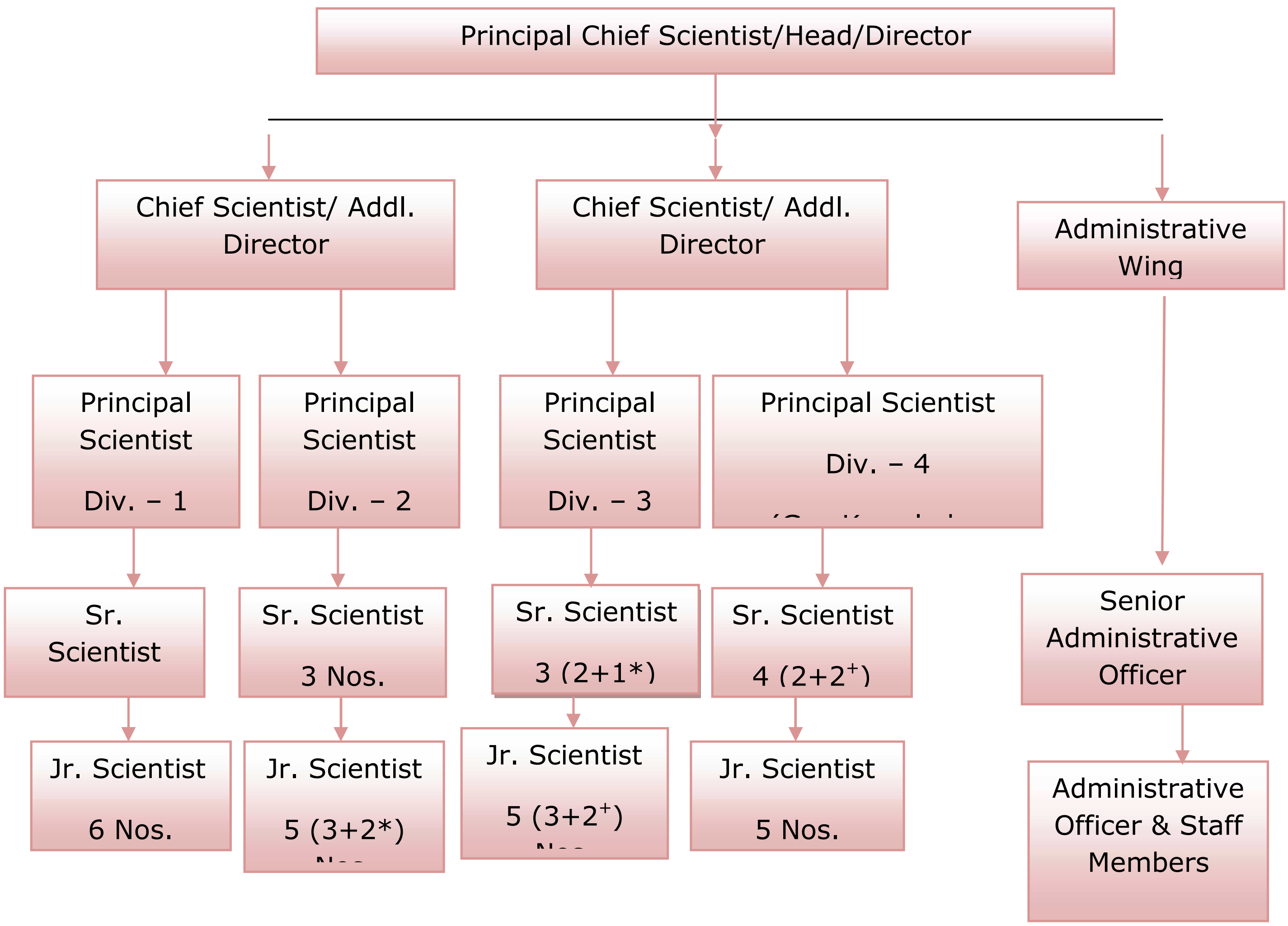
- Towards integrating climate change and disaster risk reduction and mitigation strategies in planning

Manpower Requirement

The institute will be headed by a renowned scientist to be designated as Principal Chief Scientist/Head/Director and the rest of the Scientists will be working in four (4) divisions as mentioned above (Figure 11.1).

In addition to the scientists, there will be support personnel to manage general administration, accounts and IT services to all the divisions. At present it is presumed that a total number of 40 Scientific personnel and 30 number of Administrative staff are basic requirement for the institute. The details are furnished in Table – 11.2 and 11.3. Provision for Technician grade manpower to be identified by the Divisional Heads as per requirement in due course.

Figure 11,1: Organizational Structure & Manpower strength of the proposed Institute



Total Scientific Grade Manpower – 40 Nos.
N.B.
* IT personnel – to provide services to all the divisions.
+ Post(s) to be filled up with Social Science background/basic discipline.

Table 10.2: Suggested Pay Scale of the Scientific Personnel

1.	Principal Chief Scientist/ Head/ Director	-	PB 5 :	Rs.37,000 – 60,000/-; G.P. Rs.10,000
2.	Chief Scientist/ Addl. Director	-	PB 5 :	Rs.37,000 – 60,000/-; G.P. Rs.8,900
3.	Principal Scientist/ Divisional Heal	-	PB 5 :	Rs.37,000 – 60,000/-; G.P. Rs.8,700
4.	Sr. Scientist	-	PB 4 :	Rs.9,000 – 40,500/-; G.P. Rs.7,600
5.	Jr. Scientist	-	PB 4 :	Rs.9,000 – 40,500/-; G.P. Rs.5,400

Table 10.3: Suggested Pay Scale of the Administrative Personnel

Sl. No.	Category		Pay Band	Pay Scale	No. of Posts
1.	Sr. Administrative Officer	-	PB 4 :	Rs.9,000 – 40,500/-; G.P. Rs.7,600	1
2.	Administrative Officer & DDO	-	PB 4 :	Rs.9,000 – 40,500/-; G.P. Rs.5,400	1
3.	Accountant; Section Officer; Cashier (one each)	-			3 (1+1+1)
4.	P.A. (to be attached with the Higher Officials upto the rank of Div. Head)	-	As per existing Pay Scale of the Govt. of West Bengal.		7
5.	UD and LD Assistant	-			3 (1+2)
6.	Attendant/ Messenger (Group-D)	-			15
Total :					30

Total Cost of setting up the institution
Manpower: Rs 25 Lakh/year
Infrastructure cost: Rs. 1.00 Cr 1st year, and Rs. 30 Lakh from next year onwards (to be housed within WBPCB, only cost of hardware and software included)
Cost 12th Plan: Rs. 2.45 Cr
Cost 13th Plan: Rs. 2.00 Cr

Focus on Special Regions

Chapter 12: Darjeeling Himalayas

Darjeeling Profile

Physiography: Darjeeling is the northernmost district in West Bengal. It is located in the eastern Himalayas at an altitude of 6710 feet, extending from 27o13' N to 26o27'N latitude, and 88o53'E to 87o59'E longitude covering an area of 3149 km2. The district is bounded by state of Sikkim in the north, Nepal in the west and Bhutan on the northeast. Geographically the district can be divided into two broad divisions, the hills which are a part of the eastern lower Himalayas and a stretch of the territory lying along the base of the hills known as Terai. The hilly areas rise as high as 3657 m above sea level and the Tarai region is only 91 m above the sea level.

The soil is chiefly composed of sandstone and conglomerate formations, which are the solidified and upheaved detritus of the Himalayan range. However, the soil is often poorly consolidated and the permeable sediments of the region do not retain water between rains, therefore not considered suitable for agriculture. The area has steep slopes and loose topsoil, leading to frequent landslides during the monsoons. According to the Bureau of Indian Standards, the town falls under seismic zone-IV[35], near the convergent boundary of the Indian and the Eurasian tectonic plates and is subject to frequent earthquakes.

In the hilly terrain the soils are predominantly acidic in nature and is shallow to moderately shallow but also deep at places, well drained, coarse-loamy to gravelly loamy in texture. These soils occur on steep side slopes. They are classified as *Typic Haplumbrepts* and *Typic dorthents*. In the foothills of Himalayas and in piedmont plains the soils are deep to very deep, imperfectly drained and coarse-loamy to fine loamy in texture and are placed in Aquic Ustifluvents and *Fluventic Eutrochrepts*.

The entire hilly region of the district comes under Darjeeling Gorkha Hill Council, an autonomous administrative body under the state Government of West Bengal. The council covers the three hill subdivisions of Darjeeling, Karseong and Kalimpong and 13 mouza's of Siliguri. The foot-hills of Darjeeling Himalayas, come under the Siliguri subdivision. See Figure 12.1.

Climate: Due to high variation in altitudinal differences in aspects the climate within the hill areas vary greatly. In general the hill areas enjoy pleasant summer, heavy rain in rainy season due to strong monsoonal winds and cold winter with snowfall in higher altitudinal areas. The annual mean maximum temperature of the hilly region is around 14.9^{o}C and minimum temperature is 8.9^{o}C, with lowest minimum temperature goes below zero. In the Tarai region the temperatures are higher and range between 3 to 15^{o}C in winters and do not exceed 35^{o}C in summers. The average annual rain fall in the Hilly areas of the district is around 2092 days with number of rainy days spanning over 126 days and varies between 2500-3500 mm. In the Siliguri district or the Tarai region average rainfall is 3620 mm which spread over 113 days annually and varies between 2000-2500mm[36]. See also Table 12.1

[35] on a scale of I to V, in order of increasing proneness to earthquakes

[36] http://www.banglarkrishi.gov.in/final/climate.aspx *for Darjeeling district and its subdivisions, accessed on 9th March, 2012*

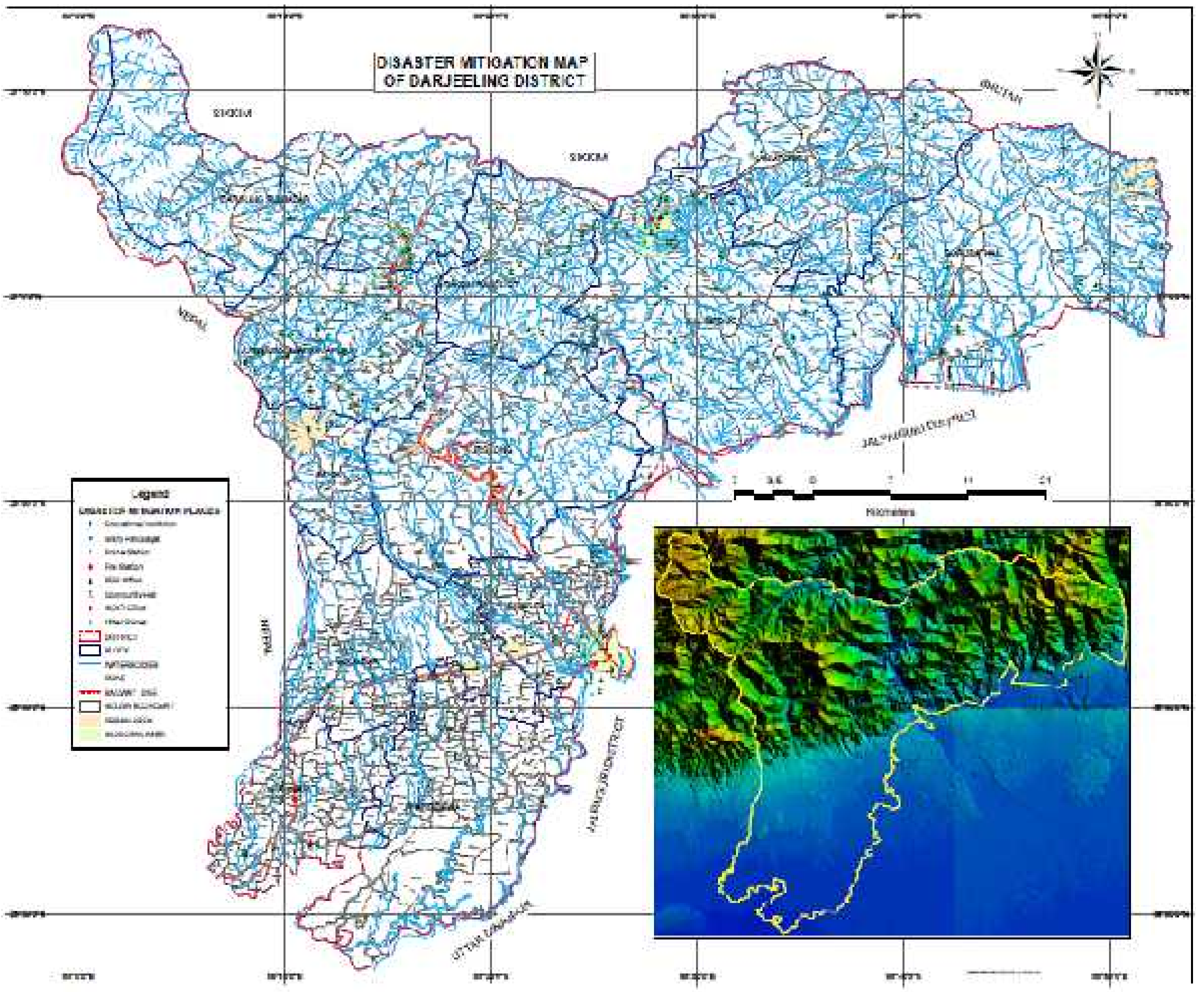


Figure 12.1:Darjeeling District and drainage map[37].

Table 12.1: Monthly mean maximum, minimum temperatures and rain fall for the period 1901-2000 for the district of Darjeeling[38]

	Max temp (oC)	Min temp (oC)	Mean Rain fall (mm)
January	9.4	1.8	19.7
February	10.4	2.9	24.1
March	14.4	6.3	47.7
April	17.4	9.4	115.8
May	18.5	11.5	197.2
June	19.3	13.6	570.0
July	19.4	14.3	781.7
August	19.6	14.2	635.3
September	19.2	13.3	437.3
October	18.0	10.3	122.5
November	14.7	6.3	23.5
December	11.5	3.3	7.0

Water resources: The rivers flowing through Darjeeling district are Teesta, the Rangeet, Mahanada, Balason, Jaldhaka, Rammam, Mechi, Lish, Gish, Chel and Murti. Each of the rivers as they flow across the district are also fed by an innumerable perennial and seasonal streams or Jhoras originating from numerous springs across the hills as also decipherable from Figure 10.1.

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37 Source: http://darjeeling.gov.in/GIS/DARJEELING.pdf

38 *Source: http://www.imd.gov.in/doc/climateimp.pdf; accessed on 8th march 2012.*

The average rain fall over the district is of the order of 2781.8 mm and the surface water availability in the district is 527.8 BCM. The trans boundary water availability is of the order of 16.25 BCM (refer also to chapter 5 of this report). The net ground water availability in the district is 0.52 BCM[39].

The dynamic ground water resources in the non-hilly blocks of the district covering Siliguri as estimated by CGWB and SWID of Gov of Wes Bengal is shown in Table 12.2[40]. The groundwater development in the three North Bengal districts, viz., Darjeeling, Jalpaiguri and Coochbehar are quite low being only 5%, 4% and 17% respectively which are much below the State average. These three districts are, however, bestowed with about 18% of the State's available groundwater resources[41].

Table 12.2: Ground water characteristics in the Terai region (Siliguri)

Net Ground water availability	46957 ha m
Existing gross ground water used ofr irrigation	1700 ha
Existing ground water draft for domestic and industrial water supply	807 ha m
Allocation of domestic and industrial req. supply for next 25 yrs	1719 ha m
Stage of ground water development	5.34%

Land Use: As of 2003-2004, out of the total reporting area of 325469 ha, forest area was 124574 ha. Area under non agriculture use was 33785 ha, barren and unculturable land was 4925 ha, permanent pasture and other grazing land was 909 ha, land under miscellaneous tree groves not included in net sown area was 1942 ha, culturable waste land was 1376 ha, fallow land including current fallow was 14953 ha and net sown area was 143003 ha. The land use distribution is shown in Figure 12.2.

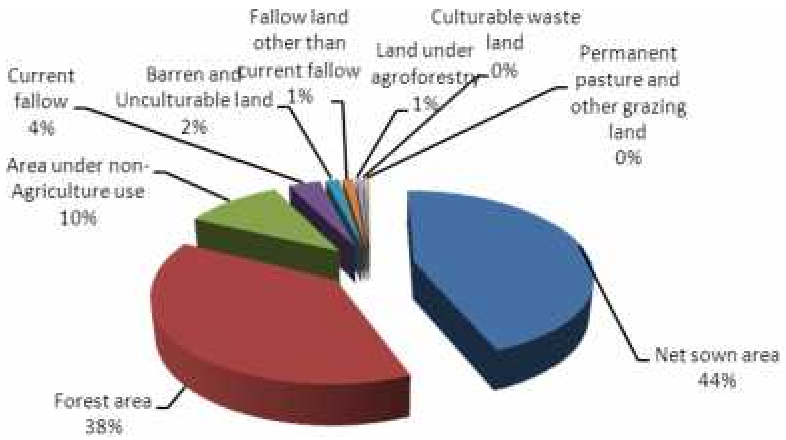

Figure 12.2: Land use of Darjeeling District[42]

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[39] Water Resources and its Quality in West Bengal, Status of Environment Report, West Bengal Pollution Control Board, 2009 (WBPCB, 2009).

[40] Ground water information booklet, Darjeeling district, West Bengal

[41] State Agriculture Plan for West Bengal, accessed from http://rkvy.nic.in/SAP/WB/WB.PDF on 9th March 2012

[42] District Statistical Handbook- Darjeeling, 2004. Bureau of Applied Economics and Statistics, Govt. of West Bengal

Demography: According to the 2011 census Darjeeling district has a population of 1,842,034. The district has a population density of 585 inhabitants per km^2. Its population growth rate over the decade 2001-2011 was 14.47 %. The sex ratio is 971 females for every 1000 males, and a literacy rate is 79.92 %. In 2001, the total population of the district was 1,609,172. The total rural population was 1,088,740 and total urban population was 520,432. Total males were 830,644 and total females were 778,528. The density of population was 511 per km^2. The decennial population growth rate (1991–2001) was 23.79% and between 2001 and 2011 it has decreased to 14.47%. The average literacy rate increased from 71.79% to 79.92% between 2001 and 2011. Also see Table 12.3.

Table 12.3: Population features of Darjeeling in 2001 and 2011

Description	2011	2001
Actual Population	1,842,034	1,609,172
Population Growth	14.47%	23.79%
Density/km2	585	511
Sex Ratio (Per 1000)	971	937
Average Literacy (%)	79.92	71.79

Agriculture: In the hilly regions of Darjeeling, farming on terraced slopes is a major source of livelihood for rural inhabitants, mainly concentrating on growing fruits, vegetables, maize, medicinal plants, cardamom amongst others. In the terai region, bulk of the rice is produced from this district. The main food crops grown in the entire Darjeeling districts include Rice, Wheat, Barley, Maize, Millet, Buck wheat, Winter potato, Summer potato, Summer vegetables, winter vegetables, Bhodai vegetables, Cardamom, Mustard, Ginger, Turmeric, Kalai, Soyabean[43]. The trends of growth of area cropped, crop production and yield of some of the key crops is shown in Figure 12.3.

Biodiversity: The geographical continuity of Darjeeling Hills with Nepal, Bhutan and Sikkim and the unique climatic conditions has resulted into a mosaic of floral and faunal elements which is rich, both in forms of luxuriance and species diversity (See Box 12.1). A study carried out by Alfred et al.[44] to assess the present status of biological diversity in the State of West Bengal reflects a greater concentration of various species in areas of lower human population density and agricultural land-use. It seems from the data that species richness is highest in two major zones of North and South Bengal. Both these zones have a moderate density of human population and land-use for agricultural purpose. The vegetation type across the state clearly shows the highest diversity level and species richness in Darjeeling district, where human population density is also low (see Figure 12.4a). The study identifies about 4166 species in Darjeeling, of which 3166 species are Anthropods[45]. The Floral assemblage is also the highest in Darjeeling district (2439) amongst all districts in West Bengal with respect to species number as well as in terms of diversity. Also the floral and faunal richness in the region has a maximum density and shows direct correlation with low population of the region (Figure 12.4b).

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[43] http://darjeeling.gov.in/agriculture.html; accessed on 9th March 2012

[44] JRB Alfred, AK Sanyal, A Roy, S Tiwari, S Mitra and B Bhatta; Biodiversity in West Bengal- A demographic Approach; Zoological Survey of India; accessed from www.zsienvis.nic.in/Docum/WBBiodiversity.com

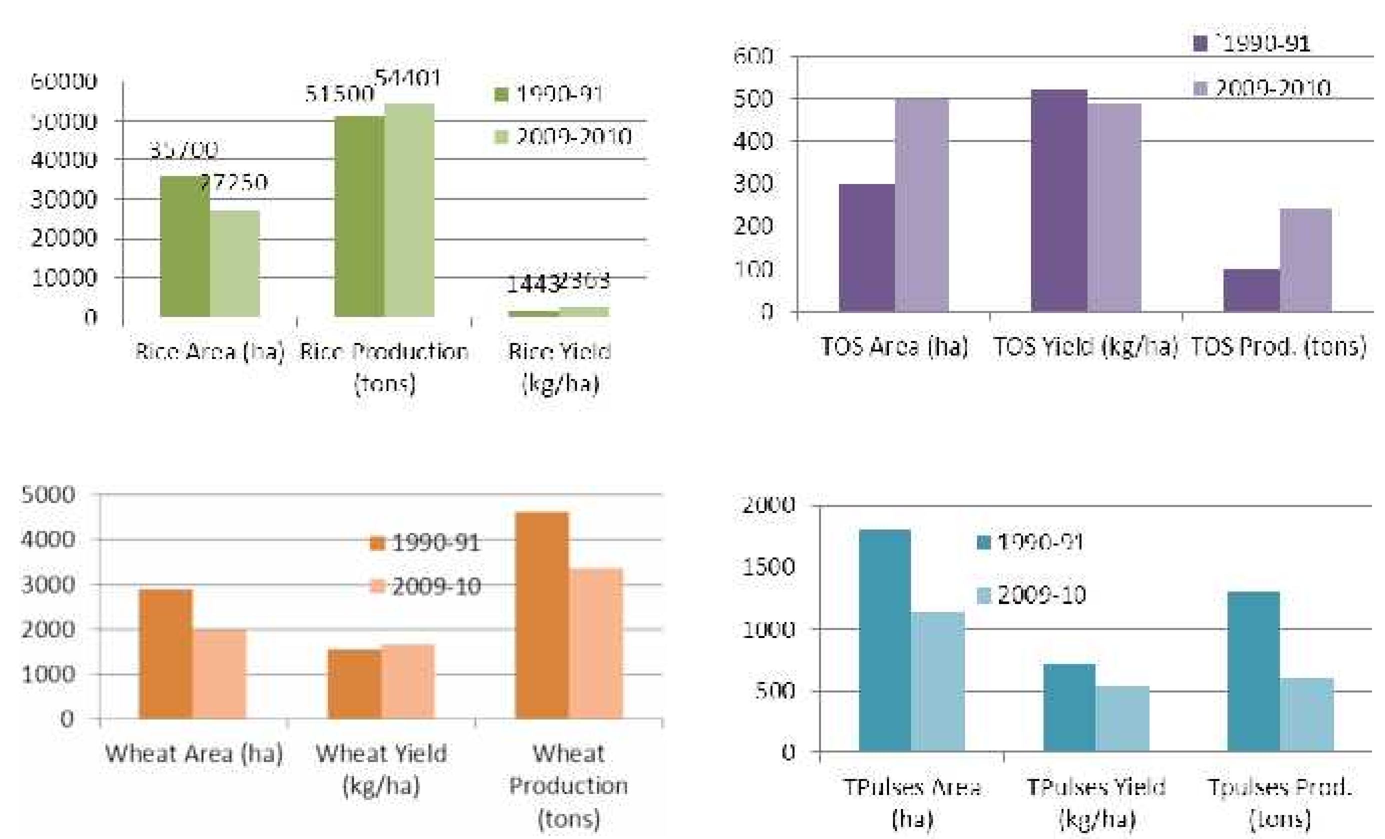

Figure 12.3: Trends of area, production and yields of main crops in Darjeeling[46,47]. TOS is total oil seeds

A paper published by Das et al. in 2004[48], based on 22 year of observations in Darjeeling Himalayan region, concludes that the flora of the region comprise 2137 species belonging to 898 genera and 193 families, of which ca 1900 species in 772 genera and 159 families belong to Dicots and the rest to the Monocots. While in 479 species (404 Dicots, 75 Monocots) are endemics, 114 species are exotics which have become permanent denizens in the flora of Darjeeling Hills. The flora is also rich in medicinal and other economically important species, including NTFPs. While a number of species could not be relocated in the region, *ca* 222 species have been considered endangered, of which 104 species occur within the protected areas, thus covered under in situ conservation.

[46] Final Estimates of PULSES and FOODGRAINS in West Bengal during 2009-10; Accessed from http://wbagrimarketingboard.gov.in/Crops/foodgrains.html on 9th March 2012

[47] District Statistical Handbook, Darjeeling 2004.

[48] Das, A.P. 2004. "Floristic studies in Darjeeling Hills". Bull. Bot. Surv. India 46(1-4):1-18

Box 11.1: Biodiversity of Darjeeling Himalayas

Trees: In the Terai area -Sal with Champ, Chilauni, Chikrassi, Gamar, Lali, Lasune, Panisaj, Paccasaj interspersed with riverian forests of Khair, Sissoo, Simul, Toon etc. representing succession from riverian to climax sal. Between 1650-3000m- Kawla, Lkhar, Pipli, Oaks (buk & phalat), Rani champ, Abies densa, Tsuga brunoniana, Acer spp are common. Between 3000-3700 m in the subalpine region Putli, Lekh Kapasi, Lekh Pipli, Kapasi, Arupate, Sindure Katus(Castanopsis sp.), Yew (Taxus bacata), Tsuga brunoniana, Abies densa, Junipers, Birch (Betula utilis), Rhododendrons, Salix, Berberis, Maling bamboo are found.

Flowers and other plants: More than 4000 varieties of flowering plants. About three hundred varieties of ferns, including tree fern and countless types of flowerless plants, mosses, algae, fungi, birches, and of course, the prize orchids, wild and cultivated.

Fauna: Monkeys, wild cats, tigers, leopards, civets, jackals and foxes, wild dogs, bears, otters, martons, weasels, squirrels(including the Himalayan flying and Assam giant varieties), porcupines, hares, barking deer, sambhurs, chitals, the very rare pangolin and now the Red Panda is also found in the Darjeelingforests. In the foothills and the teria forests, in the sanctuaries (Jaldhapara and Gorumara in the neighbouring Jalpaiguri) can be seen the gaur or Bison, elephants and the single horned rhinoceros.

Birds: Darjeeling is the home of six hundred varieties of beautiful birds like flycatchers, fairy bluebirds, orioles, finches, sunbirds, long-tailed broadbills, Kaleej pheasants, tragopan, Munal, sibia, minivet, magpie, hornbills, woodpeckers, rufous piculets, emerald cuckoos, three-toed kingfishers, long-legged falcons, Hoogson's imperial pigeons, emerald doves, besides a large number of seasonal migratory birds on their way to the plains.
Source: http://darjeeling.gov.in/flora.html; State of the Forest Report – West Bengal, 2009-10.

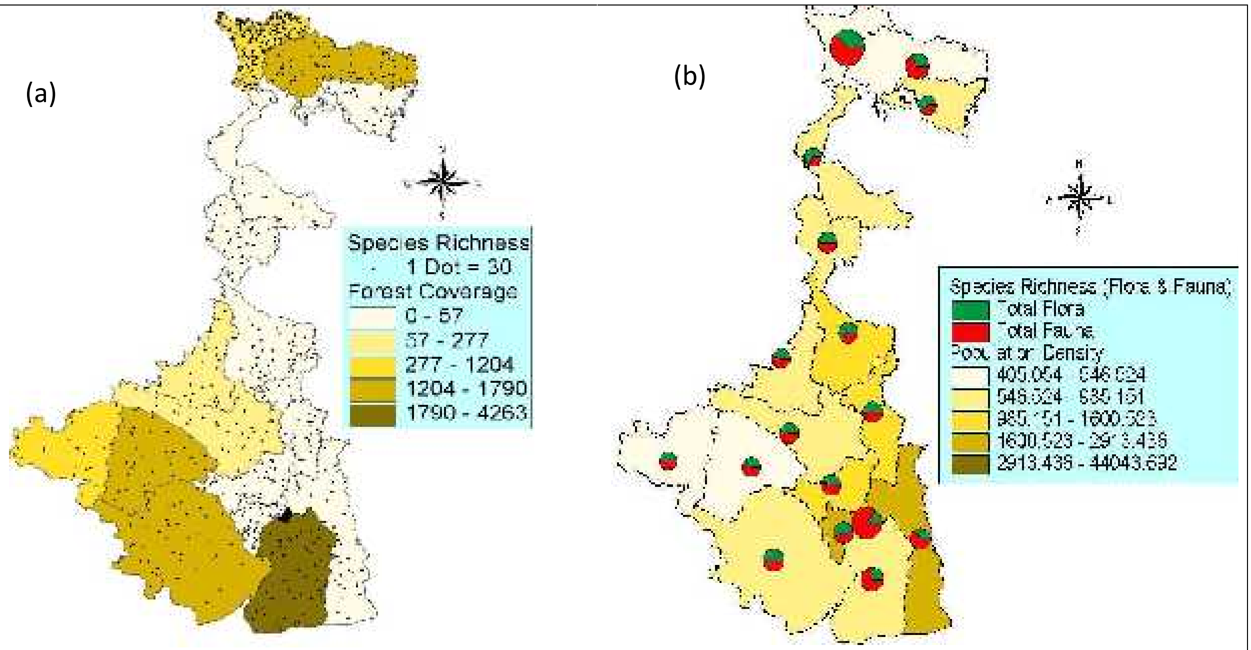

Figure 12.4: Species richness and (a) Forest cover (sq km) and (b) Population density[12].

Forests: As of 2010, the notified forest area in Darjeeling district is 1204 km², of which 1115km² is reserved forest area and 89 km² is unclassed forest[49]. The recorded forest area is 38.23% of

[49] State of Forest Report 2009-10, West Bengal, Department of Forests, Govt. of West Bengal.

the total geographical area of the state of Darjeeling district. Of this 43.43 km^2 is degraded forests[50].

The forest survey of India, defines the total forest cover as the actual forest cover plus the trees outside forests. The State of The Forest Report of Forest Survey of India, 2011[51], estimates that the total forest cover in the Darjeeling district is 2289 km^2, which is 72.69% of its total geographical area of 3149 km^2 and 17.61% of the total forest cover in West Bengal. Area wise the forest cover of Darjeeling however ranks 4th amongst all the districts in West Bengal, after Medinipur, Jalpaiguriu and South 24 Parganas.

Between the 2001 and 2011 assessment of the FSI, the Forest cover of the Darjeeling district shows an increase from 2196 km^2 to 2289 km^2, thus indicating a net increase of the order of 4.24% (See Figure 12.5). Of the total forest cover assessed by FSI 2011 State of the Forest Report, the area under very dense forest , moderately dense forest and open forest were 714km^2, 663km^2 and 912 km^2 respectively. Between 2001 and 2011 assessments, the dense and moderately dense forest area have decreased from 1417 km^2 to 1377 km^2– a decrease of 2.8% area. Where as within the same period the open forests have increased from 779 km^2 to 912 km^2 between 2001 and 2012, which is an increase of 17.1% (see Figure 12.6).

Forest fires reported from the Darjeeling district show a decline. In 2006-07, about 135 forest fires were reported affecting 825.80 ha covering the forests areas in Darjeeling, Kalimpong, Kurseong and Wild Life I. In 2009, the forest fires reported were 20 in Darjeeling and Wildlife I and the area affected was 58ha. The total encroached area within the forests in the district in 2006-07 was 236.86 sq km in Kurseong, Kalimpomg, Wild Life I and Wild life II and 2009-10 it reduced to 132.35 sq kms.

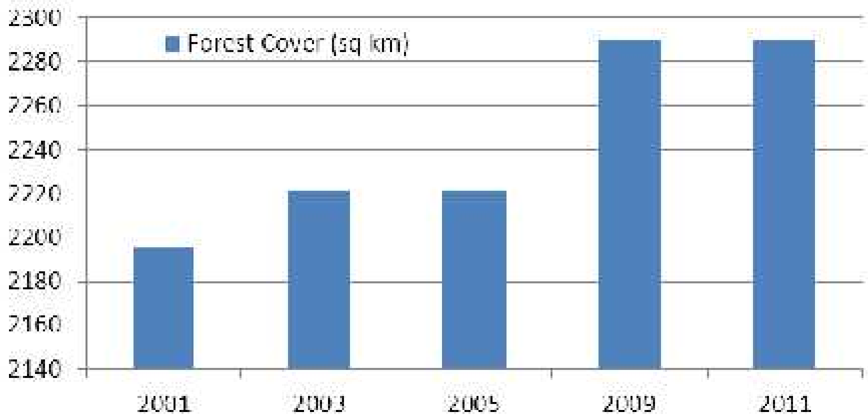

Figure 12.5: Trends of forest cover of Darjeeling between 2001 to 2011[52]

[50] Wastelands Atlas of India, 2005. Published by Ministry of Rural Development, Deptt. of Land Resources Govt of India and NRSA, Deptt. of Space., Govt of India.
[51] India's State of the Forest Report, 2011; Accessed from http://www.fsi.org.in/cover_2011/westbengal.pdf on 17th March 2012
[52] Report of the State of the Forests of India, FSI, GOI

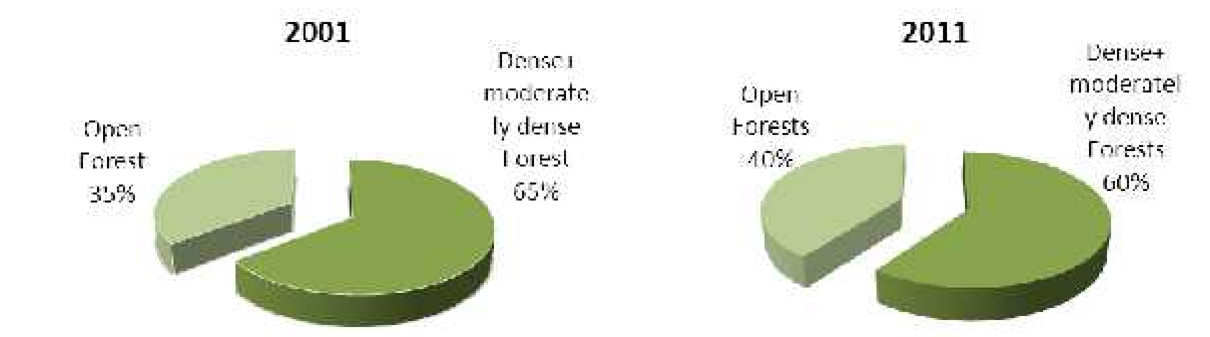

Figure 12.6: Change in type of forest cover between 2001 and 2011

Box 12.2 : Cause of Fragmentation of Forests in Darjeeling

Illegal felling of trees from forests some 25-30 years back has lead to the invasion of **Mailing Bamboo** in the Darjeeling dense forests. This has now encroached in many forest areas that are not protected leading to fragmentation of forests.

Source: Discussions with Mr Tamang, Range Officer, Darjeeling District

Tea: Tea is one of the key commercial crops grown in Darjeeling and is sought after world wide for its unique flavour. The industry in Darjeeling employs 52000 people on a permanent basis and about 15000 on a casual basis for plucking tea between March to November of which more than 60% are women[53].

Tea was first planted in the early 1800s, the incomparable quality of Darjeeling tea is grown over about 17,500 hectares of in 87 estates in and around Darjeeling spread across 7 valleys at altitudes ranging from 200 to 2000 m on slopes with altitudes between 60^{o}-70^{o}. The very high rainfall spread over various months is a boon for tea cultivation. Rainfall, humidity, evaporation rate, wind speed, hours of sunshine, mist, cloud and fog are also important factors in developing the unique quality of Darjeeling tea. In terms of soil, the average carbon level of soil in Indian tea-growing areas other than Darjeeling is less than 1%, while it is much higher in the Darjeeling area. See Table 12.4 for the typical climate, physiographic and geographic characteristics that create the unique flavor of Darjeeling Tea.

More than 60% of the tea bushes grown in Darjeeling belong to the small-leaved Chinese variety, *Camellia sinensis var. sinensis*,. This Chinese hybrid is found almost nowhere in the world outside China and Japan, except for Darjeeling and the Caucasus. It is easily identifiable because of its smaller leaves. This cultivar along with the climate conditions enables the production of volatile flavour constituents (V.F.C.) which are the main architect of Darjeeling flavor[54]. The V.F.C. content in Darjeeling tea is three times more with respect to tea from other areas in the country.

[53] http://darjeelingnews.net/tea_facts.html
[54] Mahanta & Hazarika (!985). Improve Flavour – Quality assured. Two & a Bud. 32 (1 & 2) : 25 – 29

Table 12.4: Climate, Physiographic and geographic drivers for the typical flavor of Darjeeling Tea[55]

- Altitude 200 metres to more than 2 000 metres above sea level
- Latitude 26°31' to 27°13' north
- Longitude 87 ° 59' to 88 ° 53' east
- Rainfall Average annual rainfall ranging from 1700 to 2 500 millimetres
- Humidity Very high, with fog, mist and occasional snow
- Soil Rich and loamy: in the uplands it is usually red, gritty and residual, i.e. derived from the weathering of underlying rocks and rich in organic matter from the surrounding forest cover
- Slope Gradient of 60 ° to 70 °: these steep slopes provide natural drainage for the generous rainfall received in the seasonal monsoons
- Temperature 1 ° C to 11 ° C with a maximum of 20 ° C
- Sunshine Average of 2 to 4 hours per day
- Tea-growing areas Seven valleys, facing the Himalayas

There has been a fluctuating productivity of Darjeeling tea in recent years. Between 1991 to 1998 the production of tea declined by about 37% and in the next few years picked up again upto 2008. In 2009 and 2010 a declining trend in production has again been observed[56]. The area of production has more or less stabilized at 17500 ha from 2001 onwards. The average yield is also hovering between 500-650 kg/ha (see Figure 12.7), The average yield is however 3 to 4 times less than that of tea from Assam and the Terai regions in West Bengal[57]. Tea yields in the southern region of India are also much higher – around 2.5 to 3 times that of Darjeeling tea. Therefore the national average yield of tea is more than 3 times higher with respect to Darjeeling tea yields at 1800 kg/ha.

However, due to exclusivity of the product, Darjeeling tea commands a higher price with respect to tea produced from other areas in the country. Even within West Bengal, the price differential between tea produced in Terai region and Dooars with respect to Darjeeling tea is almost two times. Also the price has been increasing over the years (see figure 12.8)

Medicinal and Horticulture plantation: Darjeeling grows Cinchona trees, the bark of which is used for extracting the life saving Anti-Malarial drug Quinine. It also produces Ipecac Cephaelis ipecacuanha, Indian Gooseberry, and Dioscorea Composita Hemsl, chirota and..... Darjeeling also grows other horticulture crops of commercial value such as Darjeeling Mandarin, potato's, Cardamom, Rubber, Mulberry, Turmeric, Taxus bacata, Broom stick, Citronella, Vetiver, Lemongrass, and Artemisia annua.

Mandarin oranges is one the best known horticultural products of Darjeeling and are grown in an area of around 3.58 '000 ha and the production is around 33-35 '000 tons. Through the Directorate of Cinchona and other medicinal plants, 1400 MT dry Cinchona Bark were sold at Rs.5.25 crore (approx.) during 2007-08. But it is a loss making venture (Making losses of the

[55] Darjeeling tea, India; Tarit Kumar Datta, Indian Institute of Management Calcutta. Accessed from http://www.fao.org/docrep/013/i1592e/i1592e03.pdf

[56] Source: Tea Board

[57] http://www.teaboard.gov.in/pdf/stat/Productivity07.pdf

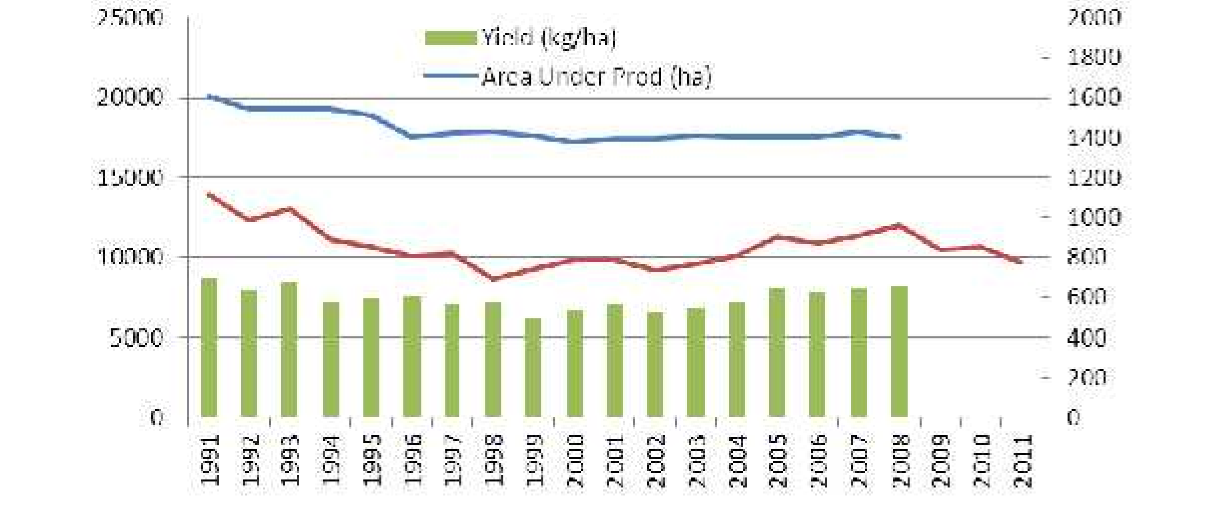

Figure 12.7: Trends of production (1991-2010), yield (1991-2008) and area of production (1991-2008) of Darjeeling tea. The Y axis on the right represents the yield[58,59].

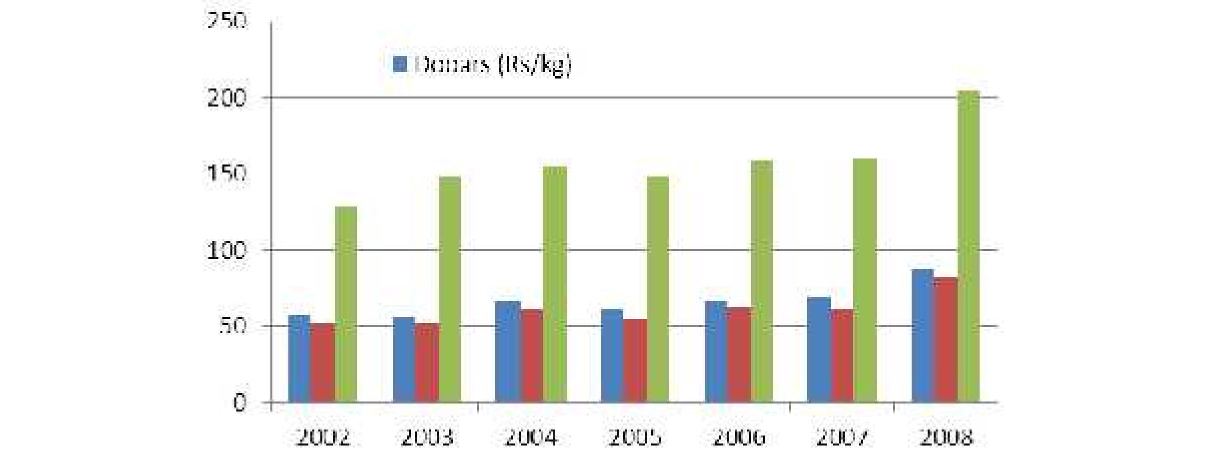

Figure 12.8: Price trends of Darjeeling Tea in comparison to tea produced in Dooars and Terai regions of West Bengal[60]

order of Rs 2.0 Cr annually) and the directorate is diversifing to production of oranges and rubber.

Darjeeling hills are the natural home for orchid species like *Cymbidiums, Vandas, Dendrobiums, Paphiopedilums, Lycaste, Odontoglossum, Phaius, Arundina* etc. The hills have limitless scope for production of Gladioli cut flowers to cater to the demand of both the

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58 Darjeeling tea, India; Tarit Kumar Datta, Indian Institute of Management Calcutta. Accessed from http://www.fao.org/docrep/013/i1592e/i1592e03.pdf

59 Tea Board; Accessed from http://www.teaboard.gov.in/pdf/stat/Monthly%20Production.pdf

60 Source: Tea Board, Accessed from www.wbplan.gov.in/htm/ReportPub/EcoRev09-10/Econ_Review_2009-10.pdf

domestic as well as the export market. Cut flower started being traded over three decades back. Today other cut flowers, besides Gladioli are anthuriums, Orchids particularly Cymbidiums, bulbous flowers of lilies, ornithogalum. Additionally flowers like gerberas, carnations and greens like ferns are also grown here[61].

Tourism: Tourism, is roughly a Rs.500 crore industry in Darjeeling and bout 500,000 domestic and foreign tourists visit the region every year[62]. According to the Indian Hotel Industry survey report published by HVS[29], the tourist inflow is decreasing in Darjeeling (see Figure 12.9). The political unrest has contributed greatly to the situation. Tourism in Darjeeling is confined within April to June and from September to October period leaving out the rainy season because of frequent landslides. However, the economic benefits of tourism reach only a small proportion of the population.

The rich flora and fauna, the hilly sub tropical and alpine landscape, and the climate are the factors that drive tourist influx into the Darjeeling district. The major attractions are the view of the Kanchanjunga peak and the eastern lower Himalayan range; the flora and fauna of the various national parks, botanical gardens, zoo, Tea gardens, and the various forest and hill treks; the eco-tourism centers at Lava, Lulegaon, Mongpong and Paren under Kalimpong sub-division, and Lepchajagat in Darjeeling; the heritage train ride; and the religious places like monasteries and pagodas and the Mirik lake. These sites are spread across the Darjeeling, Kalimpong, Kurseong, and Mungpoo.

Figure 12.9: Trends of Occupancy rates in Darjeeling hotels. ID means Indefinite Data[63]

Forest Products[64]**:** The forest products from Darjeeling district include timber, fuel wood, grazing grass, and minor forest products such as honey, wax, sal seeds, and citronella grass. The Darjeeling district has 8 saw mills spread over Darjeeling, Kurseong and Kalimpong that handle timber and the total capacity of these saw mills is 6439 Cu m. In 2009-10, the Kalimpong region

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[61] http://darjeeling.gov.in/floriculture.html

[62] Red Panda – ATREE- Eastern Himalaya Regional Office News Letter, vol 1, Issue 2, July 2008; accessed from http://www.atree.org/newsletters/redpanda/redpanda_1-2.pdf

[63] Indian Hotel Industry Survey, 2008-09, 2009-10 and 2010-11, accessed from http://www.hvs.com

[64] Source: State of the Forest Report, 2009-10, West Bengal. Published by Deptt of forest, Govt of West Bengal

produced 825 m^3 of round timber and 151 m^3 of firewood. The total amount of revenue earned from timber, firewood, grazing, minor forest products, and other products produced in the Hill region was Rs. 2.79 Crores. Of this, revenue earned for selling timber was Rs. 2.24 Crores, sale of firewood earned Rs. 7.40 lakhs, garzing earned revenue of the order of Rs. 0.01 lakhs, minor forest products were sold for Rs. 16.51 lakh and other products were sold for Rs.30.82 lakh.

Habitats: The urban population in Darjeeling district as of 2011 was 7.18 lakh which is 2.46% of the total urban population of West Bengal[65]. The decadal growth rate in urban population of Darjeeling district between 2001 and 2011 is 38.0%. The main urban centres of the district are the Darjeeling town and the Siliguri town. The other smaller urban centres being the towns being Kalimpong and Kurseong in the hills.

Water is supplied to Darjeeling town from the twin Senchal lakes which get water from 26 springs from the catchment area of Senchal Forest and wildlife sanctuary located about 15 km away[66]. In the Siliguri town, potable water is supplied from to 30 wards out of 47 wards from the Tista-Mahananda link canal and from three deep tube wells.

The urban water supply status of the Darjeeling district is shown in Table 12.5. Only 13.99% of the population in Siliguri, 35.25% of population in Darjeeling, 19.37% in Kurseong and 4.23% in Mirik get direct piped water. However, in Kalimpong the direct connections cover a larger population – about 87.06% of the total population of the town. Rest of the population in each of these towns are getting water from stand posts.

Table 12.5: Status of urban water supply in Darjeeling district as of 31.3.2010[67]

Sl. No.	Name of Town	Urban Population		Safe Water Supply Coverage						Per Capita Supply
		2001 Census	March 2010 (anticipated)	House Connection		Stand Post		Total		
				Population	%	Population	%	Population	%	
1	Siliguri	425213	493247	69000	13.99	285350	57.85	354350	71.84	57.79
2	Darjeeling	107530	124735	43964	35.25	44424	35.61	88388	70.86	69.90
3	Kalimpong	42980	49857	43405	87.06	4993	10.01	48398	97.07	85.87
4	Kurseong	40067	46478	9005	19.37	18064	38.87	27069	58.24	63.31
5	Mirik	9179	10648	450	4.23	5751	54.01	6201	58.24	52.90

Through the JNNURM programme, in Siliguri town, supply of potable water to 31-44 wards covering a population of 7.9 lakhs is being targeted to be completed by 2038. The proposed level of water supply is 70 LPCD. Plans are on to increase the water supply to 135 LPCD. Laying of distribution network in these wards to ensure connectivity to all households is on[68]. The state government through the state funds will further augment Water supply to wards 45, 46 and 47. Water for Siliguri town is drawn from river Mahananda and in the future water will also be drawn from river Teesta. Augmnetation of water in the Darjeeling town is being done through Roongunkhola scheme and the Balason River scheme by the Darjeeling Hill Council. Roof top water harvesting is also being done additionally to augment the water availability in the town of Darjeeling (1 scheme) and Kalimpong (6schemes). Also the Nerokhela scheme will

[65] http://censusindia.gov.in/2011-prov-results/paper2/data_files/wb/4-pop-7-16.pdf
[66] http://www.darjeelingmunicipality.org/waterworks/Waterworks.aspx
[67] http://www.wbphed.gov.in/applications/im/uploads/001026.pdf
[68] http://urbanindia.nic.in/programme/ud/uidssmt_pdf/UIDSSMT_Photos.pdf

supply piped water to Kalimpong from two perennial springs Nerokhela and Dhaulakhola located 65 and 72 km away. This scheme will also cover rural areas enroute.

The rural population in Darjeeling, according to the 2011 census is 11,23,859 which 61.01% of the total population of the district[69], 929 rural habitations in plains and 1050 rural habitations in the Darjeeling Hill Council Area[70]. As of 2009-10, 50 rural habitations in the plains are not yet covered by potable water supply, 94 are partially covered, 800 are fully covered. Therefore 83.42% of the rural population in the plains of the Darjeeling district have potable water supply. The source of water for rural population in the plains are the 1170 Tubewells of which 20 have low water table. In the DGHC area, 49 habitations are not covered, 97 are partially covered and 889 habitations are fully covered. Therefore water supply coverage is for 69.02% of the total rural population in the area[35].

Energy: Power supplied in the Darjeeling district is a mix of hydro and thermal. Jaldhaka I & II, Teesta Stage I, II, and III, and Ramman Stage III HEP-NHPC are the three Hydro power projects of capacity 35 MW, 67.5 MW and 50 MW respectively that are supplying power to the Darjeeling district[71]. The oldest hydropower station - Sidrapong in Darjeeling having a capacity of 600 KW was commissioned in 1897, is currently being renovated by WBREDA[72]. The thermal power to the district is mainly fed from the Farakka thermal power stations in West Bengal.

Due to proximity to the forest areas, the fuel wood consumption in the rural areas of the Darjeeling district is one of the highest in the state. A study carried out by Forest Department West Bengal indicates that the per capita consumption of fuel wood in the rural areas of the Darjeeling district is around 1305 kg/capita[73]. An indicative statistics of fuel wood extraction trends in the Darjeeling area (Kalimpong subdivision) can be found from the data published by the Forest department (see Figure 12.10). The extraction fuel wood rate varies highly across the years but is not reflective of the consumption rate, as the demand may be met from sources other than the forest department extraction source.

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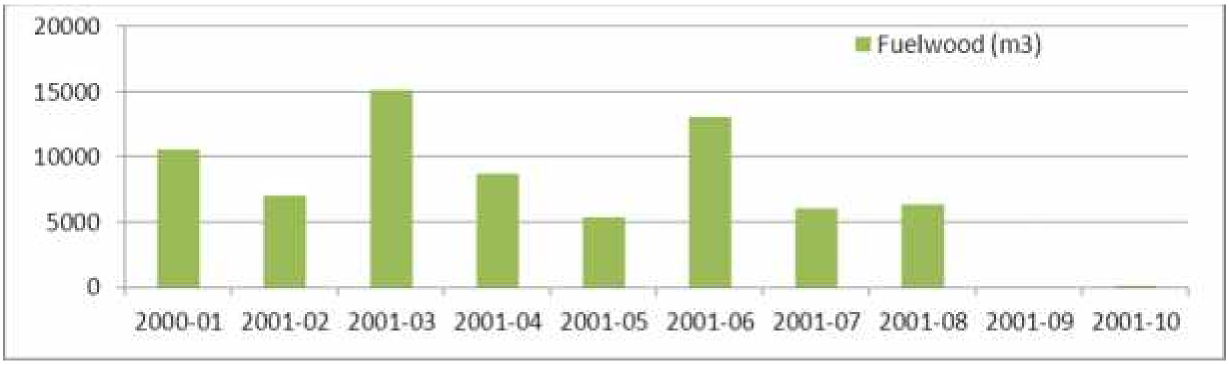

Figure 12.10: Trends of out-turn of fuel wood from Kalimpong district

69 http://www.census2011.co.in/census/district/1-darjiling.html
70 http://www.wbphed.gov.in/Static_pages/habitation_covered.html
71 CEA CO2 emission Data base 7.0
72 http://www.wbreda.org/energy-small-hydel.htm
73 Source: Anon. 1987. Wood balance study West Bengal (Unpublished). Planning and Statistical cell. Chief Conservator of Forests, West Bengal Forest Department. Study cited in Book by Devendra Pande, 2002. Fuelwood studies in India, Myth and Reality. Published by Centre for Forestry Research in India. Bogor Barat. Indonesia.

Human Health: Diarrhoeal and Respiratory diseases are the two most prevalent diseases in Darjeeling (see Figure 12.11). Diarrhoeal diseases mostly occur due to consumption of un potable water. The respiratory diseases in the districts are due to multiple causes, but mainly due to inhalation of soot emanating from burning of fuel wood in all households and vehicular fumes from diesel run transport vehicles plying in the hills. Vector borne diseases like malaria are prevalent in the district, and are found more in the foothills. The health infrastructure is listed in Table 12.6.

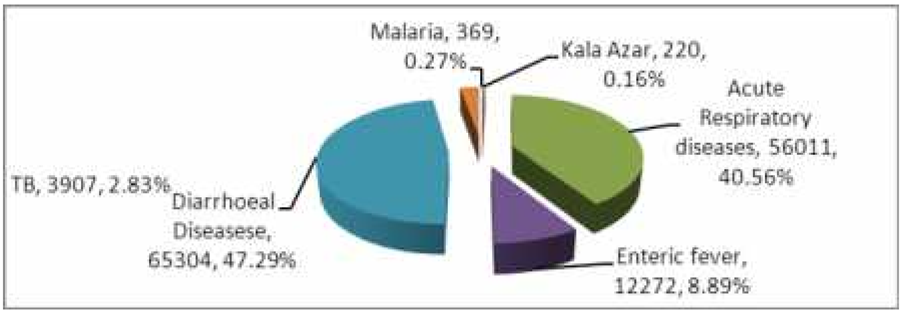

Figure 12.11: Diseases prevalence in Darjeeling districts in 2010[74]

Table 11.6: Existing Heath Infrastructure in Darjeeling District[75]

Number of Government Hospitals	51
Number of private hospitals	111
Number of sub centres	230
Number of PHCs	23
Number of CHCs	12

Governance: The Darjeeling hill area is under the Darjeeling Gorkha Hill Council which was established under the provision of Darjeeling Gorkha Hill Council Act, 1988 with the objective of total social, economic, cultural and education upliftment of Gorkha and other communities of people living in the Hill areas of Darjeeling District. The jurisdiction of the Hill Council covers an area of 2476 Sq. Km. covering three revenue Sub-Divisions of Kalimpong, Kurseong and Darjeeling and 13 mouzas of Siliguri Sub-Division and has control over 19 development subjects.

On July 18, 2011 a tripartite pact was signed between the Union Government, the top leaders of Gorkha Janmukti Morcha and the Trinamool Congress government in West Bengal leading to the creation of Gorkhaland Territorial Administration (GTA). The new administration will be vested with powers to regulate 54 subjects. The agreement envisages more powers for the Darjeeling Gorkha Hill Council, or DGHC. Essential services like in health, education and water supply sectors could improve as per the new pact. Gorkhaland Territorial Administration will

[74] Health Statistics. Department of Health and Family Welfare, Government of West Bengal, Accessed from http://www.wbhealth.gov.in/Health_Statistics1.asp?pass_file_id=25&stat_main_id=100 on 18th March 2012
[75] http://www.scribd.com/doc/50928270/RHS-FINal-West-Bengal

have territorial jurisdiction over the three subdivisions of Darjeeling, Kalimpong, Kurseong. Governance of Tea estates under the Council is still under discussions.

The Terai region of the district including Siliguri is under the Darjeeling District Administration of Government of West Bengal.

Current concerns of Darjeeling district

Water availability

Inadequate coverage of drinking water supply: Water is sufficient in the Terai region of the Darjeeling district, however, the only problem is in its distribution for drinking water vis a vis coverage of habitations, which is being addressed through the JNNURM prgramme which is part of the Rajiv Gandhi Rural Water Supply Mission of the GOI.

Heavy run off during monsoon: In Darjeeling district, four fifth of the total annual precipitation pours within June – September. Most of the water in monsoon runs off without being collected across the steep slopes, and as a result, only a small percentage of it is available for various uses.

***Water scarcity in the non-monsoon months*:** During the lean period (January to May) there is a water stress situation in the hill region. An acute drinking water crisis exists due to lower stream flow in the 26 springs feeding to the twin Sinchal Lakes. Further, the matter is exacerbated by the skewed distribution system and significant distribution losses made in the old British water supply system.

Land slides

Geological composition of rocks: The mountainous region of Darjeeling district belongs to the parts of the active Himalayan Fold-Thrust Belt (FTB), which is geologically and structurally complex exposing a number of overturned (towards south) and thrusted sequence of variably metamorphosed pelitic and psammitic rocks over the foreland sediments of Mesozoic (Gondwanas) and Tertiary (Siwaliks) sedimentary rocks in the south. Due to its complex geological and structural setting, the rocks in this region are of variable competence and are traversed by a number of penetrative discontinuity surfaces, which represent evidences of its complicated multi-phase deformation. In most parts of the Himalayas, therefore, the rocks are highly folded, thrusted and are affected by both ductile and brittle deformations. Moreover, due to active tectonic behaviour of this FTB, geomorphic adjustments in landforms are quite rapid and somewhat continuous, which are frequently represented by numerous denudational landforms in this region in the form of medium to large landslides, continued ground subsidence etc. followed in the down slope by thick accumulation of colluvial deposits. The above inherent geological factors make this active FTB fragile and more prone to various forms of gravitative geomorphic processes[76].

Monsoon rainfall and cyclonic events: Other than tectonic movements leading to land slides, landslides get triggered during heavy monsoon rainfall and even by cyclonic winds reaching

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[76] Inspection note on the recent field visit (7th to 8th September 2011) to different landslide-prone stretches in Darjeeling Himalaya By Dr. Srinivas Madabhushi, Deputy Director General & H.O.D., Geological Survey of India,
Eastern Region, Kolkata; Accessed from www.portal.gsi.gov.in/gsiDoc/pub/inspection_note_ddg_hod_er.pdf

this region. For example, Darjeeling district was severely affected by the cyclone storm Aila in 2009. Heavy landslides occurred as a result of incessant and heavy rainfall along with gusty winds for which conduit systems of connection Springs and Jhoras Balason River as source were greatly damaged, pipelines of Neorakhola Water Supply schemes were completely damaged at many sections on account of landslides and uprooting of trees.

The most landslide prone areas are:

- Stretches along NH-31 (hatisure, Berik, 27 Mile landslide near the vicinity of Tista Low Dam Hydel Project - Stage-III, 28 Mile landslide on NH-31A, Lukuvir rockslide, NH-31A)[38]
- Stretches near Darjeeling town and along NH-55 and SH-12A sections (Darjeeling-Ghum section of NH-55, SH-12A covering landslides at Balason, Margaret's Hope and Ambutia landslide from Mirik ridge, and Gayabari Tea Garden on Sh-12A)[38]

Agriculture

Limited scope for multiple cropping: Agriculture of the region is mainly Rainfed and the season is distributed within Pre-Kharif and Kharif seasons. Cultivation in drier months is limited to small patches where residual moisture / limited irrigation from nearby rivulets are available.

High runoff and soil erosion during Monsoon: Almost all arable lands have a slope of more than 8%. In some extreme cases poor farmers are seen cultivating very steep slopes of 40% or even more. During monsoon, the excess water runs off fast across these slopes leading to heavy soil erosion and hence loss in soil nutrient.

Inability to conserve run off in hilly areas for irrigation in lean period: Since the annual rainfall is mainly concentrated between June to September, the hill farmers face surplus water for five months and acute scarcity during dry months from February to May.

Soil conditions: In the hilly areas of Darjeeling, the soil in general is shallow, medium to light textured, surface drainage is rapid. It is highly susceptible to erosion by water and internally is well drained with reasonably high in organic matter, poor in bases and phosphate and distinctly acidic in nature. In the Terai region, the soil is acidic, sand laden, prone to Sheet & rill erosion, gully formation, and susceptible to stream bank erosion. Mining activities also affect the top soil.

Lower development of irrigation in the terai region: The terai region has sufficient ground water, but this region within the Darjeeling district has had very low ground water development ~ of 5% only of its potential.

Biodiversity and Forests

A number of floral and faunal species in Darjeeling district are rare and/or threatened. Some of them have been recorded by various authors. A list of some of the rare and threatened species is shown in Table 12.7.

Table 12.7: Threatened flora and fauna in the Darjeeling area[77,78]

s.no	Family	Scientific_name	Rdb_status	Distribution sites &_average altitude
Flora				
1	ACERACEAE	*Acer hookeri*	Endangered	Darjeeling, 600-1500 m.
2	ACERACEAE	*Acer osmastonii*	Endangered	Darjeeling (endemic), Salombong, Birch hill.
3	ACERACEAE	*Calamus inermis*		Kurseong
4	APIACEAE	*Pimpinella tongloensis*	Endangered	Endemic to Singaleela range in the Darjeeling-Sikkim Himalaya.
5	ARECACEAE	*Phoenix rupicola*	Rare	450 m.
6	BEGONIACEAE	*Begonia scutata*	Rare	Darjeeling, Peninsular India. 1000-1500 m.
7	BEGONIACEAE	*Begonia satrapis*		Darjeeling
8	BEGONIACEAE	*Begonia rubella*		Darjeeling
9	CAMPANULACEAE	*Codonopsis affinis*	Rare	Darjeeling and Sikkim Hiamalaya. 1830-3335 m.
10	COMMELINACEAE	Tricarpelema giganteum		Darjeeling
11	ERICACEAE	*Rhododendron edgeworthii*		Darjeeling
12	ORCHIDACEAE	*Bulleyia yunnanensis*	Rare	Darjeeling hills.
13	ORCHIDACEAE	*Cymbidium eburneum*		Darjeeling
14	ORCHIDACEAE	*Diplomeris hirsuta*	Vulnerable	Darjeeling. 1500-2000 m.
15	POLYPODIACEAE	*Christiopteris tricuspis*	Indeterminate	Darjeeling.
16	RANUNCULAEAE	*Aconitum ferox*		Darjeeling
17	RUBIACEAE	*Hedyotis brunonis*	Rare	-
18	RUBIACEAE	*Hedyotis scabra*	Rare	-
19	RUBIACEAE	*Ophiorrhiza lurida*	Rare	Darjeeling. 300-1500 m.
20	THELYPTERIDACEAE	*Christella clarkei*	Vulnerable	Darjeeling. 4000 m.
21	THELYPTERIDACEAE	*Metathelypteris decipiens*	Rare	Darjeeling
22	VITACEAE	*Cissus spectabilis*	Endangered	Endemic to Sikkim and West Bengal.
Fauna				
1	Red Panda	*Ailurus Fulgens Fulgens*	Endangered	Eastern Himalayas incl.Darjeeling
2	The snow Leopard	*Uncia uncial*	Endangered	Darjeeling
3	The Clouded Leopard	*Neofelis nebulosa*	Endangered	Thrives at altitude upto 2000 mts
4	The Salamander	*Philautis Dubious*	Endangered	Sangalila Park

[77] Red Data Book Plants of India (Nayar and Sastry 1987-88), accessed from http://oldwww.wii.gov.in/nwdc/threatened_plants_westbengal.pdf

[78] Checklist of Rare and Threatened Taxa of West Bengal, Taxa: 14; Source: ENVIS Centre on Floral Diversity. Botanical Survey of India, Ministry of Environment and Forests, Government of India; Accessed from http://indiabiodiversity.org/content/checklist-rare-and-threatened-taxa-west-bengal

Population Pressure

In recent decades, greater access to the global market has increased the demand for natural resources in the area encouraging both immigration from outside and movement within the Darjeeling region. The conversion of forests and grasslands for agriculture and settlements has led to deforestation and habitat fragmentation in Darjeeling.

Over exploitation of natural resources

The flora of fragile alpine meadows has been overexploited for traditional medicine (because medicinal plant collectors invariably uproot the entire plant, regrowth is retarded). Further, harvesting of large quantity of seeds are making some species slide to rare to rarer status, for example, the endemic cold hardy palms Trachycarpus latisectus (Windamere Palm) of Darjeeling Himalaya[79]. There are many other overriding besides seed harvesting, which are also contributing to this. Fuelwood collection and non-timber forest product extraction, both for domestic consumption and export, has inflicted severe damage to some forest ecosystems. Unplanned and poorly managed tourism has led to environmental deterioration. Widespread logging, both legal and illegal often occurs on extremely steep slopes, resulting in severe erosion and hence affecting biodiversity.

Man Animal Conflict: Poaching is a serious problem in the Himalayan Mountains, with tigers and rhinoceros hunted for their body parts for traditional Chinese medicine, while snow leopards (Uncia uncia, EN) and red pandas (Ailurus fulgens, EN) are sought for their beautiful pelts.

Forest fires and Infrastructure development: Other threats to biodiversity and forest integrity include forest fires, construction of roads and dams for hydropower.

The West Bengal government through its Forest department and the Botanical and Zoological Survey of India has created a number of National Parks and Wild Life Sanctuaries that help to protect the flora and fauna of Darjeeling Himalayas (see list in Table 12.8).

Table 12.8: The wild life conservation and protected areas in Darjeeling

National Parks	Singalila	78.60 sq km
	Neora valley	88.0 sq km
Sanctuaries	Jorepokhri Salamender	0.04 sq km
	Senchal	38.88 sq km
	Mahananda	158.04sq km
Zoological Park	Padmaja Naidu Himalayan Zoological Park, Darjeeling	

[79] B. S. Kholia and Ranjan Joshi. 2010., International Year of Biodiversity - Reviewing Practices for Conservation in Eastern Himalaya and Northeast India, NeBIO (2010) Vol. 1(2)

Darjeeling Tea[80]

Productivity in Darjeeling hills as discussed earlier in the chapter low compared to other regions of India. The various reasons attributed to low production are attributed to:

Existence of Low yielding variety: 60% of Darjeeling tea belongs to China variety, which is considered to be a very low in yield.

Limiting climatic conditions: High humidity, very low sunshine hour, high rainfall, and extremely low temperature deter higher yields. It has been observed by scientists that varieties with leaves shooting up vertically are higher yielding, and appropriate climatic conditions enable vertical shooting up of leaves.

Recurrent droughts: Since 1998 it has been observed that premonsoon droughts are setting in as no rainfall/minimal rain fall is received during October to March. Recurrent premonsoon droughts are causing general reduction in size of the plants and wilting of the bushes. This happens also because the bushes have surface rooting and do not go deeper. Impacts compounded by non availability of irrigation facilities.

Low depth of soil: Comparatively low depth of good soil and stony region at shallow depth does not help the roots to go down access the moisture and nutrients at greater depths.

Increasing incidences of Pests: Excessive pest attacks are taking place. Photo and thermotropic pest population is increasing.

Age of plantation: 66% of the plantation belong to age group of above 50 years and only 16% within 10 year age group.

High use of inorganic fertiliser: Impact of over use of inorganic fertiliser especially nitrogen fertiliser impacts Muscatel flavor and is well documented by various reserachers[81,82,83]. In Darjeeling, massive use of chemical fertilizers and pesticides in the past has reduced topsoil quality and fertility, further affecting the overall natural and environmental condition of the area

Box 12.3 : Actions by GOI to address concerns in tea plantations of Darjeeling

A Special Purpose Tea Fund (SPTF) has been created by the Government of India, which is expected to contribute significantly to revival of the tea industry in Darjeeling. The programme envisages achieving the target of increasing productivity of age-old bushes over next 15 years. Rs.4761 crore is estimated to be spent in this 15 years period including expenditure of Rs. 4360 crore for the replantation programme and Rs. 401 crore for the rejuvenation programme1.

Further, an agricultural export zone for Darjeeling tea is being planned with the support from the tea board. A tea park is being set up in 70 acres of land in Siliguri. A special purpose vehicle (SPV) will be set up to develop the tea park with public private partnership. The public sector partners are Tea Board, Siliguri Jalpaiguri Development Authority (SJDA) and WBIDC.

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[80] From literature survey and in consultation with Dr. Sayyed Edward Kabir, Assistant Prof., Deptt. Of Tea Science, University of North Bengal, Siliguri

[81] Cloughley, J.B. (1983). Effect of harvesting policy and nitrogen rates on the production of tea of Central Africa.II. Quality and total value of crop Exptt. Agric. 19 : 47 –54.

***Heavy dependence on inorganic pesticides*:** Residual pesticide detected in Darjeeling tea is slowly leading to its lower appeal in the international markets.

Difficult terrain: Naturally decelerates the quantum of activities. The steepness of the slopes has made the area very prone to environmental hazards in the form of regular soil erosion and occasional landslides. Soil fertility is reduced as a result of the erosion of topsoil.

No scope of further expansion of area under tea cultivation: There exists restrictions on the expansion of the area under tea are mainly a result of topographical factors, irrigation problems, lack of an economy of large-scale production and a prohibition on forest clearing. Lack of infrastructure such as roads and bridges which makes transfer of goods expensive

High cost of production: The slopes of Darjeeling's tea estates are so steep that ploughing can be done only manually, thereby increasing production costs. The hilly terrain also increases input costs: higher procurement costs for workers' rations, maintenance of supply lines, higher fuel costs, frequent power cuts, high costs for transporting the picked leaves from the plantation to the factory, then for transporting the made tea from the processing site in the hills to warehouses in Kolkata.

Lack of adequate infrastructure: Poor infrastructure, such as roads and bridges, results in a loss of workdays and a deterioration in the quality of the tea. The transportation of goods is highly time-consuming and costly because of the poor condition of the narrow roads due to lack of maintenance. Furthermore, weight restrictions on traffic on the hilly roads – for example, vehicles with loads of more than 5 tons are not allowed to use the hilly roads of the Darjeeling area – represent another impediment to the cost-effectiveness of the tea industry.

Medicinal Plants

Some of the constraints associated with promotion of commercial cultivation of medicinal plants are:

- Unorganized production. The concept of Commercial production yet to be introduced.
- Absence of reliable information/database on production, procurement, processing and marketing channels in the State limiting the scope for identifying mapping the potential for development, addressing the infrastructure needs and market linkages.
- Lack of awareness among farmers
- Absence of a mechanism to create awareness among the farmers
- Inadequacies in input supply including plant material, technical / extension support
- Totally unorganized marketing with middlemen and intermediaries deciding the prices for the produce often to their advantage.

Tourism

Though eco-tourism is being advertised in Darjeeling to attract tourists but it does not have a focus on conservation. Consequently, ecotourism which is supposed to protect biodiversity has started to negatively impacting wild habitats and species of the region.

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[82] Utnelisvili, M.I. (1974). The effect of nitrogen fertilizer of tea productivity and quality. Subtrop. Kul't 3 : 28 – 30

[83] Wilson, K.C. and Choudhuri, R. (1969). Fertilizers and Tea quality. Two & a Bud, 15 : 92 – 95

Urban Habitats- Siliguri[84]

Rapid increase in population: The town of Siliguri because of its strategic location and business opportunities it provides, has over the last 3 decades seen a rapid increase in population. Between 1991 and 2001 there was a 221% increase in population (see figure 12.11). Rapid increase in population due to migration has lead to mushrooming of slum areas. In Siliguri, 42 slum clusters exist that house 36.8% of the total population and 31.4% of the total households of the town as per the 2001 census. The number of families dwelling in these slums are 13850.

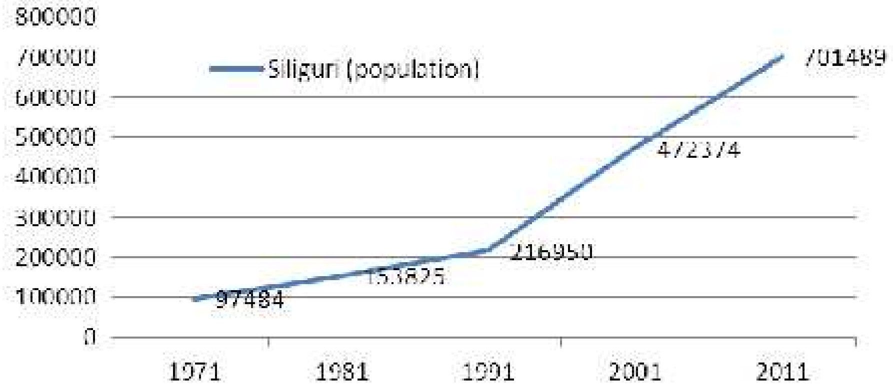

Figure 12.11: Population growth trends in Siliguri town. *Source: Census of India*

Pressure on Drinking water scarcity: Increase in population has also put pressure on direct piped drinking water supply which presently covers only 13.9% of population in Siliguri. Plans are on to cover the entire population in next 20 yrs. Also the quality of water is not uniform across the population to which it is supplied. Domestic waste water contains organic and inorganic matter which is in suspension, colloidal and soluble states in varying proportion.

Heavy traffic and transportation problems: With increase in population vehicular traffic has increased in the town, with no substantial expansion of roads. The major roads are connected only to the heart of the town where commercial activities are restricted. Narrow roads are incapable of both ways heavy traffic and eventually frequent traffic congestion occur. Since the opening up of the new bridge over river Teesta near Jalpaiguri town, the entire traffic to and from North-Eastern India follow this shorter route along Siliguri Jalpaiguri State Highway avoiding the circuitous Sevok Road route, leading to overcrowded Hill Cart Road-Bardhaman road access.

Pollution of river water: The river Mahananda in Siliguri carry raw sewage due to discharge of raw domestic and industrial sewage into the water and this is the river from which water is

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[84] Basu Roy and Sinha. 2011. A study on factors related to urban growth of a municipal corporation and emerging challenges: A case of Siliguri Municipal Corporation, West Bengal, India. Journal of Geography and Regional Planning Vol. 4(14), pp. 683-694, 18 November, 2011 Available online at http://www.academicjournals.org/JGRP
ISSN 2070-1845 ©2011 Academic Journals

drawn for drinking purpose as well. In many cases dumpsites are located indiscriminately and proper management of waste is not done. Various constituents of wastewater are potentially harmful to the environment or to public health in the Corporation. The river water and sub-surface water are vulnerable to be polluted which is used by the consumer and thereby creating intestinal disease.

Threat to biodiversity: With encroachment into share of Agricultural land, Water bodies, vacant land, for expanding town is threatening status of biodiversity and ecological components which in the future may trigger enronmental and biodiversity degradation.

Urban Habitats- Darjeeling Urban Agglomerate

High population growth rate: Between 1991 and 2001 the population in the Darjeeling urban agglomerate increased by 48%. However, the growth rate has slowed down between 2001 and 2011, and the increase is about 26% only between this period. See Figure 12.12.

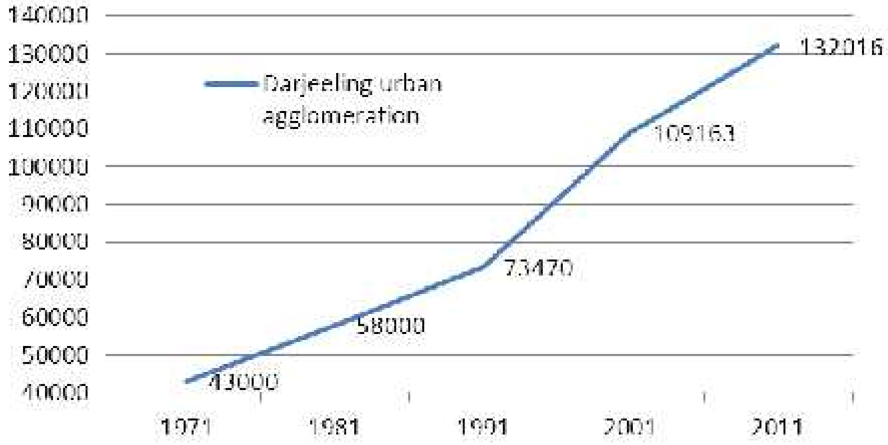

Figure 12.12: Trends of population growth in the Darjeeling town. *Source: Census of India*

High density of housing exceeding recommendation of the UDPFI[85]: The Darjeeling town has grown only along the Hill cart road with the major growth on the western slopes owing to steep slopes on the east. Existence of a single commercial center has restricted the sprawl of the town, making the city center more vulnerable to landslips, and over straining the infrastructure. The average density of the developed area is twice the recommended density by Urban Development Plan Formulation & Implementation (UDPFI) and the range of variation in the ward density is too high.

Pollution of water and choking of channels[50]: Since no systematic waste management system exists, most of the waste in the town is dumped along the Jhoras which choke the channel, pollute the water and hamper the drinking water supply.

Pressure on Housing[50]: The residential areas are characterized by high density, high-rise structures and slums. This has happened due to absence of development controls and

[85] Envis News Letter, Volume II, July-sptember 2006. Human settlements. Centre for Environmental studies, School of planning and architecture, New Delhi.

regulations, leading to increase in construction on unbuildable slopes. Being situated in seismic zone IV, these higher buildings on vulnerable slopes are potential death traps

High traffic density and air pollution[50]: Due to absence of adequate mass rapid transport system, vehicles on the road have increased leading to vehicular congestion and pollution.

Observed trends in Climate and Projected Changes in Climate

Box 12.4: Observed Trends in Climate in the Darjeeling district

- Temperatures are rising all across the district. In Darjeeling hill area the annual average temperature in the last 100 years has risen by as much as 4°C. In Klaimpong the temperature rise is of the order of 3°C
- Rainfall has become erratic in terms of quantity and timeliness
- Rainy days have decreased considerably from 165 -140 days to 155-35 days in recent years
- Relative humidity is rising rapidly
- More sunshine days observed in the hills than in the Terai region
- At times monsoon like weather extends upto November in Siliguri
- Snow fall is also erratic in the hills across the years. Poor snow fall in more number of years than excess
- Flash floods in the foot hills have increased

Source: Based on discussions and findings of Dr. Subir Sarkar, Head, Deptt. of Geography, North Bengal Univ.

The projections of climate change are for 2021-2050 with respect to base line 1961-1990 and are derived using PRECIS regional climate model with GHG drivers deduced from the IPCC A1B scenario. Details can be seen in Chapter 4.

Projected Rainfall[86]: The Darjeeling District is not likely to experience any change in precipitation during monsoon period in the mid century (2021-2050) with respect to base line (!961-199). However, it is likely to increase by 1.25 times in the hilly areas between Oct-Dec period with respect to base line. During Jan to February, there is likely to be decrease in precipitation by 0.15 times with respect to base line and a slightly lower decrease in rain fall during March to May.

Projected Extreme rainfall[87]: Number of rainy days likely to decrease by 1-5 days and intensity of rainfall likely to increase by 1-2 mm/day.

Projected Temperature[88]: The average annual maximum and minimum temperatures are likely to rise by 2.0°C to 2.2°C by mid century (2021-2050) with respect to base line.

See summary of the projections in Table 12.9.

[86] Refer to Figure 4.4 in Chapter 4 of this document
[87] INCCA Report no.2, 2010. The 4x4 assessment. Ministry of Environment and Forests, Government of India.
[88] Refer to Figure 4.5 in Chapter 4 of this document

Table 12.9: Summary of projected changes in climate in 2021-2050s with respect to base line (1961-1990) in Darjeeling Districts

Climate parameter		Likely Changes
Rainfall		
June-Sept.	=	NO CHANGE with respect to base line scenario
Oct-Nov	↑	Increase by 1.25 times wrt base line scenario for the same season
Jan – March	↓	Decrease by 0.15 times with respect to base line
April- May	↓	Decrease by 0.05 times wrt base line
Extreme rain fall		
No of rainy days	↓	Likely to decrease by 1-5 days
Rain intensity	↑	Likely to increase by 1-2 mm/day
Temperature		
Min Temperature	↑	Likely to increase by 2.0 to 2.2°C
Max Temperature	↑	Likely to increase by 2.0 to 2.2°C

Implications of climate change projections

Water resources

Impact of increase in rainfall between October to December with respect to base line: A positive implication can be drawn from this projection, as water during this season can be stored to avoid drinking water stress conditions generally seen in the hilly areas in the lean period and as soil moisture levels increase, possibility of expanding agriculture activities to Rabi season including cropping of new crops not planted earlier due to water stressed conditions can be explored.

Impact of increase in extreme precipitation events: Extreme precipitation events are a potential threat and increase in their frequency by 1 or 2 days and intensity by 1-2 mm/day is likely to lead to heavier soil erosion and landslides even in non prone areas as well and block roads and access to markets and other social infrastructure leading to extensive economic losses. The landslides are likely to damage water conservation structures and water pipes affecting drinking water availability. Farmers may be forced to abandon their farming activities due to landslides. High rate of silt loads in the streams and rivers are likely to lead to frequent flash floods during monsoon in the valleys and the plains leading to overloading of storm water drainages and waste water systems making the water from the two to mix and pollute fresh water reservoirs affecting health of the population. The flash floods then are likely to water log standing crops for a long period of time in the plains due to inadequate drainage and affect the availability of potable drinking water.

Melting of glaciers: The Major rivers flowing through Darjeeling district are originating from glacier fed (see Box 11.5) and therefore highly vulnerable to climate change. Melting of glaciers due to rise in temperatures is likely to have serious implications on water availability in this region, in near to long term future. As melting in the near future may increase the flow, but continuous recession of the glaciers with further warming, the flows are likely to decrease, converting them to rainfed rivers, and making them non-perennial.

Increase in flash floods: Increase in extreme precipitation may lead to more frequent flash floods that will flow down to the terai region causing overloading of the drainage system unless it is equipped to drainout the excess water, flood the plains, and as a consequence damage standing crops on the river plains, affect infrastructure, and potability of drinking water in these areas.

Box 12.5: Glacial origin of major rivers flowing through Darjeeling District

Teesta: Originates from Tso Lhamo lake in North Sikkim at an elevation of 5,330 m (17,487 ft) above sea level in the Himalaya. This lake is formed by the melting of the *Teesta Khantse glacier*.

Rangeet: Originates in in West Sikkim district. A perennial river, it *is fed by the melting snow of the Himalayas* in early summer and the monsoon rains in July–August. While flowing towards Darjeeling District in WB it joins the Teesta river at Teesta Bazaar on the border of WB and Sikkim.

Mahananda: The Mahananda originates in the Mahaldiram Hills in Himalayas near Chimli, east of Kurseong in Darjeeling district at an elevation of 2,100 metres. It flows through Mahananda Wildlife Sanctuary and descends to the plains near Siliguri.

Balalson river: The Balason river originates from Lepchajagat, located at Ghum Simana Ridge at an altitude of 2361 m in the Senchal Hill area.

Jaldhaka: The Jaldhaka river is formed by the conjunction of three streams - Bindu Khola, Dudh Pokhri and Jaldhaka that *originates from the Kupup lake, a small glacial lake* in eastern Sikkim. The Jaldhaka

Agriculture

Impacts on crop yields due to increase in temperature : The major crops grown in Darjeeling district such as rice, wheat, pulses, and oil seeds are likely to experience decrease in production due to rise in temperature. However, with doubling of CO_2 concentration, the yields of all crops are likely to increase with increasing temperature upto about 2°C, but beyond this if the temperature rises then the yields reduce. Except in the case of C4 plants which can use more efficiently the enhanced concentration of CO_2. Maize which is a C4 plant when exposed to doubled CO_2 concentrations, gains in yield even beyond 2°C (upto 3°C)[89]. Therefore Maize might be a preferred crop fro growing in a climate change scenario.

[89] Robert J. Redden, Shyam S. Yadav, Jerry L. Hatfield, Boddupalli M. Prasanna, Surinder K. Vasal, and Tanguy;2011. The Potential of Climate Change Adjustment in Crops: A Synthesis Lafarge; Chapter 24 in the book entitled Crop Adaptation to Climate Change, First Edition. Edited by Shyam S. Yadav, Bob Redden, Jerry S.

***Shifting up of agriculture production centers to higher altitudes and opening up of opportunity for hardy crops to grow at lower altitudes*:** In order to offset the impact of rising temperatures, higher altitudes may offer conducive climate for the current crops. However, at lower heights more temperature tolerant varieties which are generally the indigenous varieties can continue to grow.

Increase in volume of soil erosion in hilly area due to increase in extreme precipitation and land slide: Due to increase in soil erosion, it is expected that there will be loss in soil nutrient and as a result though rainfall during monsoon is not likely to decrease, but yields might still decrease. Further damage to crops and infarstrucure is expected due to heavier and frequent land slides even in non prone land slide areas. This can lead to decrease in agriculture incomes as access to markets is cut off.

Damage to standing crops in the Terai region due to flooding and in the hills due to land slides: High runoff due to extreme precipitation may lead to more frequent flash floods in the valley below i.e in the Terai region. As a result damage to standing cro frequent ps is expected. Also due to land slides damage to crops in hill region might be a recurrent feature every year.

Infestation of pests and diseases: Already increase in infestation of pests and diseases has been observed in rice in the region. Climate change and variability can lead to an

- increase in the population and life cycles of existing pests,
- an invasion of alien species of plants or animal pests,
- lead to reduction in tolerance and/or increase resistance of crops to pests and disease,
- lead to increase in food toxins (mycotoxins) such as Aflatoxin, and the appearance of new strains of toxin-producing fungi,
- loss of some wild relatives of crops that could be used to introduce desired traits in classical and modern crop resistance breeding programs,
- a reduction in beneficial organisms that are used to control pest and disease,
- a reduction in the effectiveness of safe pesticides and herbicides[90].

Possibility of harvesting additional Rabi crops: One of the positive impacts of climate change in Darjeeling district is the projected increase in precipitation during October to November period with respect to base line. This will help retain moisture in the soil facilitating intensive sowing, growth and harvesting of Rabi crops.

Forests and Biodiversity

As per the INCCA report 2010[91], no change in forest cover in the entire North Eastern Himalayan region including Darjeeling is expected due to changing climate in the mid century**.** This will enable the forests to still exist in their current area if a business as usual policy is followed.

Hatfield, Hermann Lotze-Campen and Anthony Hall, 2011 John Wiley & Sons, Ltd. Published 2011 by Blackwell Publishing Ltd

[90] http://www.spipm.cgiar.org/climate-change/-/asset_publisher/7MmQ/content/farmers-face-increased-pest-populations?redirect=%2Fclimate-change

[91] INCCA, 2010. Report no. 2. Impacts of climate change on 4 sectors in 4 regions

However, in reality, the dense forest cover including moderately dense forest cover, has reduced from 65% to 60% of the total land area between 2001 and 2011 (see section 11.1 on forests), where as open forest area has increased within the same period. Encroaching in forests and forest fires have created fragmented forests leading to loss of habitats for many floral and faunal species and reduction in realization of forest products such as timber, fuel wood, honey, rear medicinal plants and other products. Climate change can further exacerbate the situation.

Some of the likely impacts of climate change on Darjeeling Himalayan forests and its biodiversity are as follows.

Loss of habitats for flora and fauna: If the scenario of fragmentation of forests continues and dense forest areas reduce the faunal species living in these forests might have to move to higher heights to live in conducive habitats. Space crunch at higher heights can lead to competition for survival, and as a result the species can become more rear or become totally extinct. Example, the snow leopard, and the Himalayan bear etc.

Box 11.6: Epiphytic mosses reducing in Darjeeling Forests

A regular trekker in the Himalayan region, Mr Animesh Basu of Himalayan Nature and Adventure Foundation, Siliguri, during discussions indicated that in the last 30 yrs he has observed slow and steady disappearance of epiphytic mosses in the Darjeeling forests including Neora valley national Parks, Senchal, and Singalila sanctuaries which are protected). This was also corroborated by Mr. A P Das, Prof of Botany, North Bengal University who has extensively worked in the region to study the flora.

Epiphytic mosses in these forests play an important role in the hydrology of these forests. Their presence increased canopy leaf surface and better rainfall interception and absorption of moisture. Water storage by mossy epiphytes is well known. They can hold water from 1-2 lts/sq cu m (as per PHE estimates). Epiphytes also supplement with secondary metabolites providng them nesting, breeding and moisture for other biota. It is well known that Epiphytes are sensitive to climate and are the first community to show drastic response to changes in Climate.

About Epiphytes: Source: Shashidhar A N and Arun Kumar; 2009. The Indian Forester. Accessed from : http://www.indiaenvironmentportal.org.in/files/Effect%20of%20climate%20change%20on%20orchid.pdf

Shifting of the forest line to higher altitudes and slow disappearance of the subalpine forests: As temperatures increase, it is likely that the forest line will shift upwards, as the vegetation will seek suitable climate for it to thrive. As a result the area of subalpine vegetation currently thriving at 3000-3700 m may reduce or actually may be pushed out and become extinct due to lack of space in this region. The native tree species in the subalpine regions of Darjeeling that are thriving now at 3000-3700 m height are Putli, Lekh Kapasi, Arupate, Sindure Katus(Castanopsis sp.), Yew (Taxus bacata), Tsuga brunoniana, Abies densa, Junipers, Birch (Betula utilis), Rhododendrons, Salix, Berberis, and medicine alpine herbs will move upwards and some of them become extinct. Therefore, sensitivity of these different species to thermal stress is an important area of stidy.

Changes in species composition at different altitudes impacting ecosystem services and livelihoods: As temperatures rise intrusive species are likely to invade the lower altitudes and earlier leafing, flowering, fruiting, bird egg laying, spawning of amphibians, and changes the cycle of arrival of migrants and insect emergence can change the species level interactions, eventually leading to ecosystem-level changes. Changes to ecosystems can affect their ability to provide essential services, such as carbon sequestration, food provisions, and other forest products. This in turn will affect livelihood of communities dependent on forest products.

Increase in forest fires: As the climate warms, the soils are likely to be drier in the summer months as time goes by leading to conditions for forest fires to occur naturally. Forest fires may accelerate species turnover or select fire-adapted species[92]. In the same way, changes in species composition may alter fire occurrence by changing the concentration and arrangement of flammable fuels[93]. Increase in forest fire incidences would lead to increase in crop predation in fringe villages by species driven out of the forest like White Rumped vulture and Slender Billed vulture which are now rarely sited in the district.

Increase in man animal conflict: As the forest produce less, animals dependent on the same will seek food outside forests for their survival, leading to frequent man animal conflict. The Himalayan bear, is currently seen seeking its food outside the forests.

Tea productivity

The Darjeeling tea gets its typical flavour from the prevailing climatic conditions in the region. The tea bushes sustain at temperatures ranging between 1-11^{o}C and not exceeding 20oc. Grow in soils with rich organic matter with sunshine hours at least for 2-4 hrs a day, and 1700-2500 mm of annual rainfall receipt and at high humidity, fog and mist and occasional snow conditions. The flavor may be at stake due to climate change.

Tea Production centers may move to higher altitudes and lose current levels of productivity: With warmer climate as the prevailing temperatures may not be conducive to growth of the bush at the altitude it is now growing and as a result the tea production centre in Darjeeling may shift to higher altitudes, and may find lesser area at higher heights, and more difficult terrain, making production economically unviable.

Soil erosion and loss in soil nutrient likely to take place due to extreme precipitation leading to loss in productivity: Further with increase in extreme precipitation events the top soil containing organic matter that is so important for the bushes may get washed away, leaving the tea plants nutrient deficient.

More frequent land slides damaging tea bushes over large areas: Due to increase in extreme precipitation events, more frequent landslides may damage the plantations, resulting in high financial damages.

Increase in drought days likely to affect tea yields unless appropriate technology introduced: As the extreme rainfall events increase with decreasing number of rainy days, drought conditions may set in during monsoon period for longer periods of time if the rains get delayed, because of which again the growth and yield of tea is likely to get further affected with respect to what it is facing now due to doroughts.

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[92] Overpeck, J.T., D. Rind, and R. Goldberg, 1990: Climate-induced changes in forest disturbance and vegetation. Nature, **343**, 51-53, doi:10.1038/343051a0

[93] Bond, W.J. & Keeley, J.E. 2005. Fire as a global “herbivore”: the ecology and evolution of flammable ecosystems. Trends in Ecology and Evolution, 20(7): 387–394.

Increase in infestation of pests and diseases: With change in climate increase in infestations of pests (e.g blister blight, tea mosquito bug, red, pink and purple, mites, thrips, termites, red slug caterpillar, looper caterpillar, green leafhopper etc.[94])and diseases might occur or new strains of pests and diseases might infiltrate the region, leading to reduction in tea yields.

Horticulture plants

Medicinal Plants[95],[96]

Cinchona: The plant widely grows in tropical regions having an average minimum temperature of 14°C. Mountain slopes in the humid tropical areas with well distributed annual rainfall of 1500-1950mm are ideal for its cultivation. Well drained virgin and fertile forest soils with pH 4.5-6.5 are best suited for its growth. It does not tolerate waterlogging.

Clearly increase in temperature due to climate change beyond the threshold level that Cichona grows at, will impact its growth and hence impact the bark thickness from which Quinin is extracted.

Ipecac Cephaelis ipecacuanha: is also grown in Darjeeling Ipecac prefers an average rainfall ranging between 2000-3000mm which is evenly distributed across the rainy season. Maximum temperature should not exceed 38°C and the minimum not below 10°C. It thrives well in tropical mild humid climates similar to Malaysian rain forests. Virgin forest soils rich in humus are ideal for Ipecac. It prefers deep medium fertile soils which are acidic and rich in humus, potash and magnesium. Soil should be well drained and protected from wind and storm. As Ipecac grows only in shade, it can be cultivated as an intercrop, or planted in artificially shaded beds.

Here also temperatures beyond the range of sustenance, and increase in extreme precipitation with decrease in number of rainy days will have impact on the yield. Also forest soils full of humus are its original habitat. If the dense forest cover decreases as the temperatures increase due to change in species composition, Ipecac is likely to have loss of habitat and may become extinct.

Indian Gooseberry: Is a hardy plant and may acclimatize itself in the changing climate conditions. Is a source of Vitamin C.

D. Composita Hemsl: Is a form of yam and is a source of steroidal drugs. Is found at heights of 1000-3000 m. This is too a hardy plant and may survive climate change.

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[94] Gurusubramaniam and Borthakur, 2005. Gurusubramanian G. and M. Borthakur: Integrated management of tea pests. In: Field management in tea (Eds.: A.K. Dutta, S.K. Baruah, N. Ahmed, A.K. Sarma and D. Burugohain). Tocklai Experimental Station, TRA, Jorhat, Assam Printing Works Private Limited, Jorhat, Assam, India. pp. 159-172 (2005).

[95] PP Joy et al., 1998. Medicinal Plants, KERALA AGRICULTURAL UNIVERSITY, Aromatic and Medicinal Plants Station, Odakkali, Asamannoor P.O., Ernakulam District, Kerala, India. PIN : 683 549. Accessed from http://ppjoy.tripod.com/PDFs/Bk%20Medicinal%20Plants.PDF

[96] Biswas, K. and Chopra, R. N. 1982. Common Medicinal Plants of Darjeeling and the Sikkim Himalayas. Periodical Experts Book Agency, D-42, Vivek Vihar, Delhi-110032. 157p.

Fruits-Mandarin orange

Puffing of the skin occurs in Mandarin oranges due to high temperatures and high rainfall. Peel pitting[97] may also occur and damage the fruit at low temperature, high winds and low relative humidity in the winter period during Jan to April when the rainfall is likely to decrease with respect to base line. With increase in temperature fruit maturation is likely to advance which will not only impact the quality of the juice within but also reduce the period of commercialization[98]. It has been reported by the farmers that there has been an increase in the incidences of pests in Mandarin oranges over the years.

Flowers- Orchids

Orchids adapt through diverse mechanisms for survival and reproduction in inhospitable conditions creating a xerophytic environment in the canopy. In case of drier conditions (drought conditions), apart from developing morphological adaptation, many orchids exhibit physiological adaptation with Crassulacean Acid Metabolism which facilitates uptake of $CO2$ at night and fixing during day with closed stomata to reduce water loss by transpiration. However, under higher temperatures this process is likely to be affected as stomata closes under stress conditions, and may remain so even in the night.

There is an inter relation ship between orchids and other biota such as insects, butterflies, moths, wasps, flies mosquitoe's and birds that help the orchid to pollinate and germinate. Since insects are very sensitive to changes in climate, their survival will be almost the first effects of climate change and hence orchids which are dependent on them for reproduction will in turn will be affected. Further, habitat degradation and fragmentation of forests also affect survival of orchids. However, if the initial condition of degradation is overcome, orchids can survive in the secondary forests as well which are relatively disturbed[99].

Box: 12.7: Current observations of people in the Hills on flora and fauna

The blooming of flowers in the hills have now shifted to January from February. As a result the migratory birds coming to the Hills in the February is reducing effecting dispersal of pollens and hence survival of the different floral species is at stake. Earlier sparroes used to be seen all over, but now are missing in action,

A case in example is marigold, it seems their productivity has decreased over the years

Source: www.thehimalayanbeacon.com/magazine/2009/12/06/darjeeling-no-swallows-no-snow-and-soon-no-apples-either/

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[97] 'Peel pitting' in the flavedo (the coloured epicarp) of 'orange arises as chlorotic spots. These spots correspond to parenchymal flattening and collapse of a variable number of sub-epidermal cell layers, which increase in parallel with the epidermis, extending between apparently healthy zones. The first signs of cellular damage are associated with internal membrane disorganization of the plastids. Great vesiculation of the cytoplasm occurs, followed by degradation of cytoplasmic membranes and accumulation of abundant osmiophilic material, yielding amorphous and dense masses.

[98] Augusti M, Martinez Fuentes A., Mesejo C. 2002. Citrus Fruit quality- Physilogical basis and techniques of improvement. Agrociencia. Vol VI, No 2, Pg 1-16; Accessed from www.fagro.edu.uy/~agrociencia/VOL6/2/p1-16.pdf

[99] Shashidhar A N and Arun Kumar; 2009. The Indian Forester. Accessed from http://www.indiaenvironmentportal.org.in/files/Effect%20of%20climate%20change%20on%20orchid.pdf

Ecotourism

Climate change can adversely affect natural attractions of the Darjeeling Himalayas through glacier retreat, avalanches, landslides and flooding, gradual extinction of many species of flora and fauna, and damage to forest ecosystems through fire and insect infestation. Any changes in the physical characteristics of climate can potentially have negative consequences for tourism industries. In such cases, the quality and volume of tourism would likely be significantly diminished.

Urban Habitats and Transport

Other than the Pressure on urban infrastructure due to migration and increase in population in general, climate change impacts are specific and can manifest as follows:

Impacts of extreme rainfall: Extreme rain fall may lead to more frequent land slides, damaging infrastructure such as water pipes, roads in the urban areas as well.

Increase in electricity demand for additional for space cooling: In the summers, it might not be still necessary to use fans or ACs in hill towns now, however, with warming, cooling requirements in summers within residences and commercial complexes might soar up electricity demand.

Impact on Transport: Higher population in the cities/towns will lead to demand for more transport options, and if mass transport systems are not provided for, there is likely to be more vehicles on roads leading to traffic jams and higher emissions of GHGs and other pollutants.

Energy availability

Lesser availability of quality fuelwood as forests degrade and fragment: Fuel wood in hill areas is extensively used even in the urban areas for cooking and space heating. As climate change is likely to degrade forests further, fuel wood may become scarce, unless steps are taken to afforest continuously with fuel wood species that can adjust to climate change or help the population shift to alternate sources of energy for cooking and space heating. A sustainable management of fuel wood extraction can be a Carbon neutral system.

Impact on hydropower: As climate changes, glacier melt is a reality. Therefore the glacier fed rivers are likely to have good and faster flows initially, however, as the glacier recede more, flows are likely to reduce. In that scenario generation of hydropower dependent on adequate water flows might be affected leading to an energy crunch situation in the Darjeeling district.

Human Health

Higher incidences of malaria: The windows of transmission with humidity levels exceeding 55% and the temperature above 14^{o}C in the region is now limited to few months in a year. However, with increase in temperature, the transmission window of malaria vectors (14-40^{o}C) will be available for more number of months and will be compounded by the increase in humidity and therefore incidences of malaria is likely to shoot up, not withstanding control measures. The incidence level may increase much more than what it is now (refer to figure

11.11) when malaria shifts to higher and higher altitudes. Even now, Mosquitoe's are in Lava which is at a height of 7200 ft and even at the Singalila national park[100].

Emergence of other vector borne diseases not still occurring in these regions: Other vectors that are never seen in this regions may find a conducive climate to breed in.

Shorter life cycles of pathogens leading to higher incidences of vector borne diseases: Due to degradation of forests due to climate change, the micro climate may change, whereby the vectors are likely to adapt themselves by evolving shorter lifecycles, thereby multiplying faster.

Increase in O3 related deaths and respiratory diseases: Even if the vehicle population does not increase but fuel currently used are combusted in the vehicles, higher levels of ozone are likely to persist for a longer period of time as rainy days decrease and the climate warms[101]. Ozone loads and related deaths are likely to increase in the atmosphere with increase in vehicle population, with no shift towards renewable fuels. Similarly load of other pollutants including particulates emitted from burning of fuel wood for cooking, and used for space heating, is likely to have longer residence time in such climate conditions. The other drivers of increase in respiratory diseases might be increase in allergen loads in the atmosphere such as pollens as temperatures rise, and increase in molds in damp houses due to higher level of humidity in the air as extreme precipitations increase and also due to recurrent flash floods in the plains.

Increase in water borne diseases: Diarrhoeal incidences in Darjeeling district (refer to figure 11.11) are high even in the present climate and are likely to escalate as temperatures increase, with level of pollution in water increasing due to faster degradation of organic elements in water resources. Similarly, the probability of increase in frequency and intensity of occurrence of Typhoid and cholera incidences increases as well.

Rise in Malnutrition cases: With increase in temperature local produce of food crops is likely to reduce, except those which belong to C4 family. Therefore it is likely that malnutrition levels may increase as productivity oflocal food crops decrease.

Lower access to safe drinking water: As extreme precipitation events rise, leading to flash floods, the terai region may face water logging and hence access to potable drinking water might be an issue there.

Increasingly heat stroke incidences might occur: With rise in maximum temperatures by 2-2.2^{o}C, the elderly and the children are likely to be effected as their heat tolerance levels are minimal, especially in the hill areas, rise in incidences of heat strokes,

Adaptation Strategies

The Darjeeling district lying in the eastern Himalayan region is also is a part of the greater Himalayan region and hence its ecosystem is closely linked with that of the extremely complex larger Himalayan biosphere. Any changes in this biosphere due to the changing climate will affect the ecosystems thriving in the region directly or indirectly.

The National Mission for Sustaining Himalayan Ecosystem (NMSHEs), which is one of the 8 missions of India's National Action Plan on Climate Change therefore is an extremely important

[100] As referred to By Prof. Subir Saha, Head, Geography Deptt. Univerity of North Bengal.
[101] Though with increase in humidity levels, the O3 levels may come down as H2O is a scavenger of O3.

mission. It aims to have a greater understanding of the dynamics of the system for undertaking developmental works in the region that can be in sync with the changing responses of the Himalayan biosphere to climate change.

Keeping this in view therefore, the NMSHEs specifically aims to (a) carry out extensive studies to understand scientifically the complex processes affecting this eco-system, (b) evolve suitable management and policy measures for sustaining and safeguarding the Himalayan eco-system including Himalayan glaciers and (c) work with different stake holders such as the states lying along the Hilamalyan region, its people, and the different line ministries responsible for implementation of various developmental programmes to integrate climate change in the development process .

The review undertaken in this chapter clearly identifies that there are existing concerns that are hindering development of different sectors in the Darjeeling district and that climate change will heighten the current concerns unless climate proffing of development is systematically carried out. This would necessitate implementation of adaptation strategies that would essentially-

- Align themselves along the tenets of the National Mission on Sustaining Himalayan Ecosystems
- Expand the scope of the existing programmes to accommodate the impacts of climate change
- Develop and implement additional new strategies to facilitate adaptation to climate change
- Build institutional capacities and capacity of all stake holders towards understanding the pathways through which climate change manifests itself in various systems and towards building technical capacities for facilitation of implementation of adaptation action.

Water –Supply and demand side management

Develop a water policy for the district: Towards development of an efficient system for augmentation, distribution and management of water resource keeping in view the typical circumstances of the hilly and the terai regions.

Create additional reservoirs to store excess runoff water in the monsoon[102] and water from additional rainfall projected to be received during Oct-Dec period: with respect to base line in the hill region- Other than building the reservoirs, this will also entail an estimation of water demand keeping in view the increasing temperatures as well as increase in population both for the towns as well as rural areas in the future (next 100 yrs). Additionally, renovation of old reservoirs to avoid leakages, and new structure for runoff storage and rain water harvesting need to be built once areas where they can be built are identified.

Prepare for combating adverse impacts of projected rise in extreme precipitation events: Increase in frequency and intensity of soil erosion, land slides leading to blocking of rivers, roads, damage to standing crops, and flash floods are some of the adverse impacts of increase in extreme precipitation events due to climate change. Adaptation actions would include

[102] During monsoon, the two twin storage tanks in Sinchal actually receive water from only 8-10 spriings only, as additional water from other springs cannot be accommodated in these tanks.

updation of landslide prone area map of the hills, identification and implementation of appropriate measures for fortifying the identified land slide prone areas by keeping the soil mass free of moisture, increasing shearing resistance of the soil, training of streams to prevent damage, and other anti land slide measures. To avert damages due to flash floods, canals for diverting excess water in rivers can be created. Further to prevent water logging after flash floods augmenting/ renovating/dredging of the drainage system of the terai region can be planned keeping in view the likely level of water flow in the future during flash floods.

Prepare monitoring and evaluation plans to check the integration of climate change concerns in water management – This will enable the implementing agency to take mid course correction if mal-adaptation is taking place due to a certain action.

See table 12, in Annexure 1 for Adaptation strategies, actions, timelines and budgets for managing water in Darjeeling hills in climate change context.

Total Cost: 11th Plan: Rs 1237.00 Cr; 13th Plan: 1177.00 Cr

Agriculture

Some of the key adaptation strategies for sustainable agriculture in the Darjeeling district can be as follows:

Facilitate agriculture cropping centres to survive at lower latitudes even at higher temperatures: As temperatures increase the cropping centres are likely to shift upwards. Considering the space cruch in the hills, degraded forest lands that are cultivable and can be still used for cultivation can be allocated partially for such use. Or else agriculture under shades may be promoted to avoid higher temperatures. Investments in Agroforestry as well as using greenhouses need to escalate.

Promote Indigenous food crops of the region so as to maintain food security in a climate change scenario- The indigenous varieties are more heat tolerant and therefore can be promoted in the district. The actions will include identification of indigenous crops that are grown in the region such as pulses, oil seeds, rice, maize, millets etc. Creation of community seed banks will help their fast absorption in the villages. Preservation of Germ plasm of the indigenous varities would ensure availability in the future. However, impact of climate change on these varieties must be identified to develop measures to fortify them against adverse impacts when they are growing. True promotion can only take place when niche markets are identified and procurement prices of the yields are made attractive for the farmers to be encouraged to grow the same.

Undertake soil conservation measures and anti slide measures along hilly slopes growing crops to avert soil erosion and loss in soil nutrient. The activities that can be promoted include narrow bench terracing, aided natural regeneration, contour bunding of slopes, and zero tillage technology and Green manuring both in hill and terrain regions.

Promote integrated management of emerging and current pests and diseases: Develop Integrated Pest and Disease Management Plan that identifies crops suitable for a particular altitude, promotes use of certified diseases free seeds, identifies the organic fertilisers applicable, identifies the relevant bio pesticides, and other methods for avoidance of pest and diseases such as intercropping etc. farmers can be trained for producing organic fertilisers and bio pesticides

Intensify agricultural activities in the Rabi season: Excess moisture storage in soils due to additional rains in Oct-Dec in Mid century with respect to base line opens up opportunity for Rabi crops. Identify the Rabi crops that can be grown and popularize the same.

See table 13, in Annexure 1 for Adaptation strategies, actions, timelines and budgets for Agriculture Sector

Total Cost: 11th Plan: Rs 124.05 Cr; 13th Plan: 286.00 Cr

Biodiversity and Forests in Darjeeling Himalays

The key strategies for protection of biodiversity and forests in Darjeeling Himalays would ofcourse be the conservation activities being done by the government, however the following strategies will give it a climate change focus:

Plan activities to reduce open forest area, enhance quality of moderately dense forests and protect dense forests from degrading: Activities need to be planned for enhancing quality of forests would include-

- Regulation and monitoring of invasive species and identification and planting of non-native species that can survive climate change and be beneficial to the ecosystem,
- Develop packages for Integrated management of insects and pests
- Plant short rotation species in degraded forests
- Prevent forest fragmentation by conserving contiguous forest patches
- Undertake eco restoration of degraded open forests[103] and grasslands at the base of Darjeeling Himalayas [104].

Empower communities living in and around forests to manage forests for enhancing its quality, for conserving biodiversity, preventing fire and benefitting through payment for ecosystem services rendered: Within the Joint forest management activities the concept of ownership of forests by communities that live in and around forests with rights on its resources including wild life can be promoted. By undertaking conservation of forests and its resources they can realize economic returns from payment for ecosystem services rendered, payment for helping store C in the forests, and by selling wild life products that have a niche market. Additionally they can be encouraged to plant fire resistant trees in the aftermath of fires, to prevent future fires and through this also reap payment for C sequestered. Thus they can generate attractive economic returns and hence be encouraged to protect biodiversity and quality of forests and prevent forest encroachment. Ofcourse the activities need to monitored so an not to let them abuse the rights. Further continuous scientific and technological guidance needs to be provided to maximize returns. The guidance to their conservation measures canbe provided bythe forest department as planned to reduce open forests and upgrade quality of moderately dense forests.

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[103] Eco restoration approaches include using indigenous species rather than exotic species, creating species mosaics by matching species to particular sites, using species mixtures rather than monocultures, or encouraging the diverse plant understories that can often develop beneath plantations.

[104] It involves protection of area, removal of Weeds, reseeding of Grass Species, organic fertiliser Application, legume Introduction, providing soil Amendments

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Establish long term systematic monitoring of flora and fauna in Darjeeling Himalayas: College and University students can be engaged to record the existing flora and faunal species in Darjeeling Himalays and this can be repeated each year by different batches to record the changes if any and decipher the signals and impacts of climate change and devise policies and actions for conservation of the species that are threatened. The design of the project has to be precise so that each observation is revisited for verification year after year and documented for posterity.

Devise suitable strategies for conservation and facilitating species migration to adapt to climate change. : As climate becomes warmer the flora and fauna accustomed to the current climate will start shifting towards conducive climate and which is likely towards higher altitudes. To facilitate a smooth transition, conservators, foresters, academia together need to develop a master plan for species migration in the district. Conservation and creation of dedicated corridor's is one such measure.

Devise strategies for preventing man- animal conflict: The aim of this strategy is to have sustainable forests that help wild life to thrive within the limits of the forests and prevent encroachment of human population into forest areas. Undertake land use planning to ensure that both humans and animals have the space they need by creating a buffer zone between human and wild life habitation to which the wild life is not attracted.

See table 14, in annexure 1, for Adaptation strategies, actions, timelines and budgets for Biodiversity and Forests.

Total Cost: 11th Plan: Rs 1351.00 Cr; 13th Plan: 1441.00 Cr

Darjeeling Tea

Avoid shifting of production centre to higher altitudes: Research needs to be undertaken to identify and create cultivars that will adjust to the changing climatic conditions and retain the aroma and flavour of the Darjeeling tea. This will also entail identification of farming practices that will facilitate the growth and production of these cultivars. The other option is to create shade over the plantations that will minimize the effect of rising temperature. It can be in the form of tress that are not too dense.

Managing tea from adverse impacts of droughts: For sustaining tea productivity during periods of droughts immediate strategies that would help would include identifying and implementing measures to retain soil moisture such as contour trenching etc. The other strategy is to create additional water reservoirs to store water for irrigation during Oct-March when rain fall is scarce. The third strategy is to

Box 11.7: Developing drought resistant varieties of Darjeeling tea

Through mass selection process, the researchers in India have identified Darjeeling tea plants with broad leafs and deeper rooting system.

These are being grafted on tea stalks in the upper part with broad tea leaf variety and in the lower part with a variety having strong rooting system

Such plants are being raised in the nurseries and being tested now on a pilot basis for their productivity and sustenance.

Source: Discussions with Prof. JE Kabir, Department of Tea Science, University of North Bengal undertake research for developing water stress tolerant cultivars (see Box 11.5).

Combating excessive soil erosion and land slide due to likely increase in extreme rain fall: This will involve covering the soil with application of standard practices that will be suitable to tea plantations such as planting of grass/legumes/ creepers or any other that will stop soil erosion. Also will need to create structures to reduce speed of water along the contour lines – wooden barriers, bench terraces and contour bunding can be some of the options.

Managing Pests and Diseases via organic route: Enhanced levels of pests and diseases are expected with increase in temperature. Therefore it is imperative to develop Integrated pest and diseases Management Packages that take into account identification of bio fertilisers and bio pesticides. Options of using chemical fertilisers needs to be made minimal as residue of pesticides in tea does not attract buyers.

See table 15, Annexure 1 for details of Adaptation strategies, actions, timelines and budgets for protecting Darjeeling Tea productivity .

Total Cost: 11th Plan: Rs 130.00 Cr; 13th Plan: 400.00 Cr

Medicinal Plants

Medicinal Plants such as Cinchona, Ipecac Cephaelis ipecacuanha, Indian Goose berry, Medicinal yams (D. Composita Hemsl), chirota and Jinseng are some of the medicinal plants found in the Darjeeling hill areas and cultivated commercially. All have specific temperature thresholds, and soil conditions, and moisture requirements within which they survive. These conditions are changing with climate therefore some of the adaptation strategies can be:

Developing heat resistant medicinal cultivars: Research needs to be undertaken to develop cultivars that are heat resistant and still give the level of productivity to sustain commercialization.

Retention of soil moisture in natural habitats of medicinal plants – forests: As indicated earlier in this chapter, the soil moisture in the forests is decreasing due to loss in mosses, and soil cover, making dense forests getting fragmented and invested by weeds (bamboo) that can thrive on less moist conditions. Therefore conservation and eco restoration of forests is a measure through which water retenstion capacities of forest soils can be increased.

Darjeeling Manadarin orange

The key adaptation strategies can be the following:

- Facilitate drainage of water during excessive rain
- Avoid soil erosion
- Develop cultivars that are thermal resistant to enable flowering and fruiting in sync with seasonal changes
- Develop and implement packages for Integrated management of pests and diseases
- Disseminate technology through KVKs

Orchids

As the natural habitats of Orchids are in the forests, its important therefore to prevent fragmentation of forests to boost growth of epiphytes that in turn boost moisture retention in the epiphytes that help grow orchids.

See Table 16, in Annexure 1, for Adaptation strategies, actions, timelines and budgets for medicinal plants, oranges and orchids

Total Cost : 12th Plan: Rs 147.00 Cr; 13th Plan: Rs 192.00 Cr

Ecotourism

Since ecotourism is likely to remain a tourist attraction in the district if the quality of the biodiversity of the region does not deteriorate drastically. Since one of the major drivers of degradation of biodiversity is tourism, ecotourism with a focus on conservation of biodiversity with a climate change focus would help attract the tourists in long times to come. Therefore a policy on ecotourism needs to be developed for the district that will protect the biodiversity of the Darjeeling Himalayas and also boost their income of the local communities. The elements of the District policy could be as follows[105]:

- Establishing Eotourism Directorate
- The Directorate to provide
    - Uniform and inclusive definition of ecotourism across states
    - Guidelines on multi-stakeholder constitution of state directorates
    - Guidelines on criteria to monitor and incentives
    - Inputs on constitutional provisions on decentralized governance and international negotiations 3. State directorate to
- Set up a management cell and streamline processes for the following tasks
    -Develop indicators for assessment and monitoring according to the accepted definition
    - Assess proposals,
    - Register enterprises
    - Certify and monitor based on indicators
- Facilitate establishment of Institute of Ecotourism for training, research and contributing to monitoring and decisions.
- Design appropriate incentives for conservation and community benefits and tax on natural capital used in high end tourism.
- Identify and establish exclusive eco-tourism zones

See Table 17, in Annexure 1, for Adaptation strategies, actions, timelines and budgets for medicinal plants, oranges and orchids

Total Cost : 12th Plan: Rs 1.00 Cr; 13th Plan: TBD

Urban Habitats, Energy and Transport

The following adaptation strategies are suggested.

[105] http://sikenvis.nic.in/docs/eco_tourism_white_paper.pdf

A detailed assessment of water requirements and availability in the future vis a vis rising temperatures due to climate change: This will enable planning water management in the context of climate change.

Develop a blue print for addressing the additional energy requirement of the district in the context of climate change through the renewable energy route: Undertake a study to assess the additional requirement of energy and Map natural resource potential across the district – hydro, biomass including fuel wood, and solar radiation. Identify regions, target population and feasible renewable energy mix that can be used for generating electricity locally. Implement pilots in different regions of the district with different renewable energy mix models. Cover supply to 50% of the targeted population in the 12th plan and extend to rest 50% in 13th plan. The solar mission can be tapped for funding here. This also fits into the electricity policy 2003 of the government whereby disaggregated production of electricity is encouraged. In the case of fuel wood, if sustainable management practices are propagated then controlled use of this source is also a viable option within the energy mix for Darjeeling district as its C neutral

Retrofit the designs of large Hydropower reservoirs keeping in view the climate change impacts: Hydropower being the key electricity source in the Drajeeling district, it might be worthwhile to undertake an assessment of hydropower reservoir capacities in terms of water availability in the future as the rivers on which these hydropowers are made are all glacier fed. As indicated in the chapter earlier water from glaciers is likely to vary in the future with respect to current levels.

Map and treat the erosion prone areas in and around urban habitats keeping in view the likely intensity of extreme rainfall in the future in the urban centres and along roads leading to the urban centres: This advance planning and treatment will protect infrastructure and minimize damages and rebuilding costs.

Develop Integrated Transport plan for all the towns of Darjeeling district with initial focus on Siliguri and Darjeeling town: The integrated transport management plan needs to consider the ultimate aim of limiting GHG and other pollutant emissions and accommodate the ever increasing demand for transport by encouraging public transport. The elements of this integrated plan would focus on :

- Introduction of battery operated vehicles in the hill towns for mass transport system – This can be point to point as well as city to the plains.
- Creating no vehicle and walking zones in city centers
- Expansion of roads where, flyovers ever, dedicated bus corridors for rapid transport wherever possible to ease congestion in the plains; and constructing alternative roads in the hills
- Construction of walking bridges for Plains and escalators for the hilly areas
- Construction of disable friendly side walks
- Strict pollution checks
- Retiring vehicles older than 15 yrs
- Letting trucks enter cities only in the night etc.

See Table 18, Annexure 1 forAdaptation strategies, actions, timelines and budgets for Habitats, Energy and Transport

Total Cost : 12th Plan: Rs 445.50 Cr; 13th Plan: 1665.00 Cr

Combating impacts on Human Health

Bridge gaps in health infrastructure as identified in the NRHM review: The requirement of trained health professionals, health centes, testing laboratories, disgnostic centres, medicine stock and outlets etc. will meet the current requirement satisfactorily and ensure treatment of disease as disease incidences or new diseases emerge due to climate change.

Introduce communisation of Rural Health management in Darjeeling hill area: Communisation will enable management of health by the community itself with the help of trained professionals and facilitate prompt disease prevention and curative actions as the communities will audit funds flow into the villages, and use it as per their requirement of facilities and some of them can be trained for basic health curative measures.

Ramp up IDSP by seeking direct reports from the CHCs which have information provided by the communities on incidences: The Integrated Disease Surveillance Programme, is an excellent programme of the government of India to track disease amongst its population and deploy necessary personnel and items to address them. However, the intelligence has to be gathered from community level to further strengthen the same and help better manage the health system. The IDSP can also including monitoring the flow of all the services provided by all levels of health centres including funds on a regular basis. This will also enable IDSP to gather data, understand trends, create models that can help develop early warning systems to help districts to take actions in advance.

Develop telemedicine facilities in remote areas: This is especially important for enabling people in remote areas to consult specialists and then seek right suggestion for treatment. The specialists in the private hospitals and retired specialists from government hospitals can be engaged for this service.

Provide helicopter pickup for patients from remote areas: This is an important element of treatment of patients from remote areas. The district hospitals can keep this facilities or should have funds to acces these facilities for mobilization of critically ill patients from remote areas.

Undertake study to specifically identify future disease prevalence with climate change and vulnerable population: The study will enable health policy augmentation of the Deptt of health Govt of West Bengal and also will enable future planning of the infrastructure requirements to climate proof human health in the district.

Develop disaster risk reduction plans in view of likely increase in land slides due to increase in extreme events, and during disease outbreaks based on inputs from the scientific assessment: This needs to be developed jointly with the Disaster Management Authority/deptt./ division of the district. The plan is intended to ensure rapid mobilization of doctors, nurses, and other peripheral staff to the effected area and ensure post traumatic treatment etc.

See Table 19, Annexure 1, for Adaptation strategies, actions, timelines and budgets for combating impacts on Human Health

Total Cost : 12th Plan: Rs 476.00 Cr; 13th Plan: 500.00 Cr

Total tentative Cost for Darjeeling District

12th plan: Rs 3912.00 Cr; 13th plan: Rs 5661.00 Cr

13. Sundarbans

The Sundarban delta is the largest estuarine delta in the World and is spread over India and Bangladesh. The Sundarbans was originally measured (about 200 years ago) to be of about 16,700 sq km. Because of the partition of India, Bangladesh received about 2/3 of the forest; the rest is on the Indian side.

The Indian administrative region of Sundarbans lies within the state of West Bengal, and spreads over an area of 9630 sq km from 21°30' to 21°15'N and 88°10' to 89°10'E (see Figure 13.1). Of this 5363 sq kms is reclaimed area and 4267 sq km has been declared as the Sundarban Biosphere Reserve and houses some of the most exotic fauna such as the famous Royal Bengal Tiger and mangrove flora including the Sundari tree after which the region has been named. The entire mangrove area protects the inland area from the recurrent cyclonic disturbances and storm surges that occur in this area.

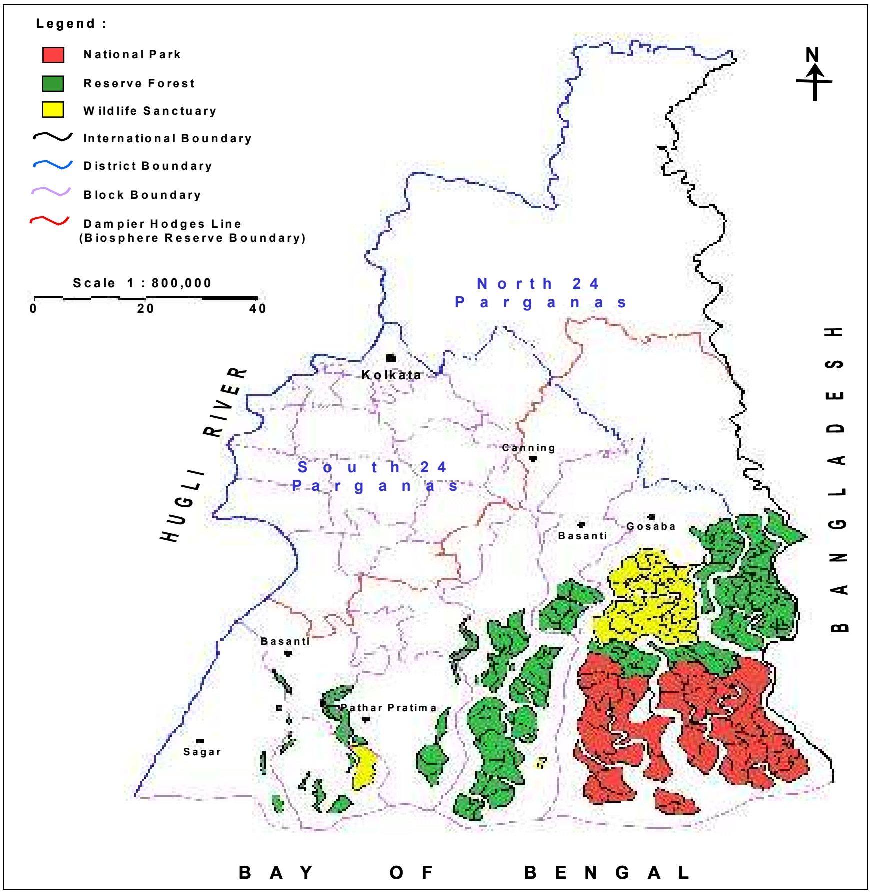


Figure 13.1 Map of Sundarbans region in West Bengal

Sundarban Profile

Physiography: The Sundarban delta has been formed by the continuous deposition of silt carried down by the Ganges and Brahmaputra river system into the Bay of Bengal for more than 70 million years. The silt load carried by the Ganges and Bramhaputra varies from 1 to 1.67 billion tones aqnnualy. A large part of the sediment reaches the sea through two marginal estuaries- Hugli in the west and Padma-Meghna in the east. But the tide pushes back a portion of sediment load through creeks and rivers. The silt-laden water spills over the flood plain during high tide and recedes during low tide and thus land along the flood plain of these rivers gets elevated. So Sundarban area is identified as active delta. The part of the delta is identified as matured when it is elevated above highest high water level. Then the area gets sediment deposit only during flood. When the rivers area decayed, the area is described as moribund delta (see Figure 13.2). The sub aqueous delta, as seen in the satellite image, extends far south from the coastline into the Bay of Bengal.

Figure 13.2: The different parts of the Sundarban Delta[106]

Despite receiving such sediment load, there has been no appreciable growth of new land along the coast during last three centuries. There are various factors which are together responsible for this condition of the delta. It is reported by the experts the delta building is impeded due to siphoning of sediment away from the coast through the *Swatch of No Ground*[107] or the

[106] Kalyan Rudra, The proposal of strengthening the embakment- Myth and reality. Accessed from http://www.counterviews.org/sunderban_aila.html ; accessed on 25th March 2012

[107] The Swatch of No Ground is a shelf canyon that deeply incises the Bengal shelf near the Ganges–Brahmaputra river mouth, cuts the foreset beds of the subaqueous river delta and acts as temporary depocenter between river mouth and Bengal fan. Sedimentation rates in the Swatch of No Ground are highest near the canyon head at B50 cm a_1, decreasing to B15 cm a_1 in 600m water depth. The canyon deposits consist of intercalated fine (silt–clay) and coarse (silt–sand) grained deposits.

submarine canyon of the Bay of Bengal. Secondly, destructive waves continuously attack the southern littoral tract and erode land. Thirdly, slow subsidence due to auto - compaction of newly deposited sediment surpasses the effect of accretion.

The important morphological features of the Sundarbans are its tidal rivers, creeks and canals, fresh water river system, beaches, mudflats, coastal dunes, sand flats, estuaries, creeks, inlets and mangrove swamps.

Climate: Due to proximity to the sea, the temperatures throughout the year in Sundarbans are moderate though it is situated in the south of Tropic of Cancer. Average annual maximum temperature is around 35°C. The summer extends from middle of March to mid June, and the winter is from Mid November to February. The monsoon sets in the middle of June and continues upto October. It experiences cyclonic disturbances between May to November, with some of the cyclones maturing into severe cyclones. The average annual rain fall is 1920 mm, most of which falls between May to October. Sundarban area is cyclone-prone, monsoonal and low-lying. This area experiences slightly more than 4 cyclonic events per year of varying wind forces.

Soil: The soil of the region can be generally classified in five groups, namely, clay soil, heavy soil, sandy loam, sandy soil and silty soil. The entire area may be divided into low salinity up to 8 ppt and moderate to high salinity from 8 ppt to 20 ppt. The salinity has seasonal variation with minimum from July to October, moderate during November to February and highest during March to June. On the whole, the soils of the region are fertile and suitable for productive agriculture but optimum use is constrained by poor drainage conditions during wet season and lack of irrigation in the dry season.

Water resources: Seven rivers flow through the Sundarbans. In the western part of the Sundarbans are the Hoogly river and the Muriganaga which originate from the Ganges river. In the Western part the 5 rivers that flow through it are Saptamukhi, Thakuran, Matla, Gosaba and Harinbhanga also had upstream connection with the ganges.

Due to heavy siltation and disposal of solid waste from adjacent cities, the rivers in the western part of the Sundarbans no longer receive fresh water from the upstream ganges and are totally tidal fed. However, these rivers do receive fresh water during monsoon which lasts for a period of May to October.

Due to continuous tidal activity, however, the surface water in Sundarbans is saline and unusable for human and livestock consumption. Sweet water or potable water is drawn from aquifers at depths 200 to 400m.

The Embankment: Between 1777 and 1971, continuous deforestation and land reclamation activities have been carried out in the Sundarbans region in the ones densely forested Mangrove area. Forests were cleared for Agriculture by the British. Clearing of forests did not however, facilitate beginning of agriculture on the flood plain which tended to

Box 13.1: Facts about the Embankment

Length of the embankment	3500 km
Number of drainage sluice	862
Maintained by Deptt. Of Irrigation and Water	
Length of river embankment	
On estuaries	700 km
Length of rive embankment	
on medium estuaries	2750 km
Length of sea dyke	50 km
Without mangrove cover	2000 km

Source: West Bengal HDR, 2009

be submerged under saline water during high tides. Therefore a 3500 km long embankment was built along the bank of creeks and along the sea shore to prevent the ingress of saline water. Thus the spill-over of silt-laden water on floodplains was also assumed to be restricted.

However the embankment impeded the dynamics of sedimentation. It made silt get trapped within the embankments and the river beds got filled with silt, making the channels increasingly shallow. As a result the river beds got elevated but the flood plains remained at the same height. Consequently, the rainwater falling on the floodplains remains stagnant for a long periods of time and the tidal inflow has been transformed into a tidal bore which breaches the embankment often..

Administrative area, Population and Land use: The area of 5364 sq. km. of non-protected area covers 54 islands and a part of the mainland as well, and has dense human settlement. Originally, around 1780s, human settlement in this region took place through clearing mangrove forests and constructing a *3500 km long earthen embankments or dyke* to protect the islands from tidal waters.

The human settlements in Sundarbans area covers the sub divisions of Kakdip, Baruipur, Diamond harbor, and Canning in South 24 Parganas district, and Bashirhat in North 24 Parganas district and is into 19 blocks of which 6 are in North-24 Parganas and 13 are in the South 24-Parganas districts having 190 Gram Panchayts and 1064 villages.

The total population in 2001 in this region was 37.56 lakhs and has grown to 43.75 lakh in 2011[108] (see Figure 13.3a). In 2001, the density of population was 929 people/sq km and about 5,40,000 households with an average size of 6.9 persons per household resided in the area. In 2011, the density has increased further with increase in population and decrease in land area to about 1082 persons/sq km.

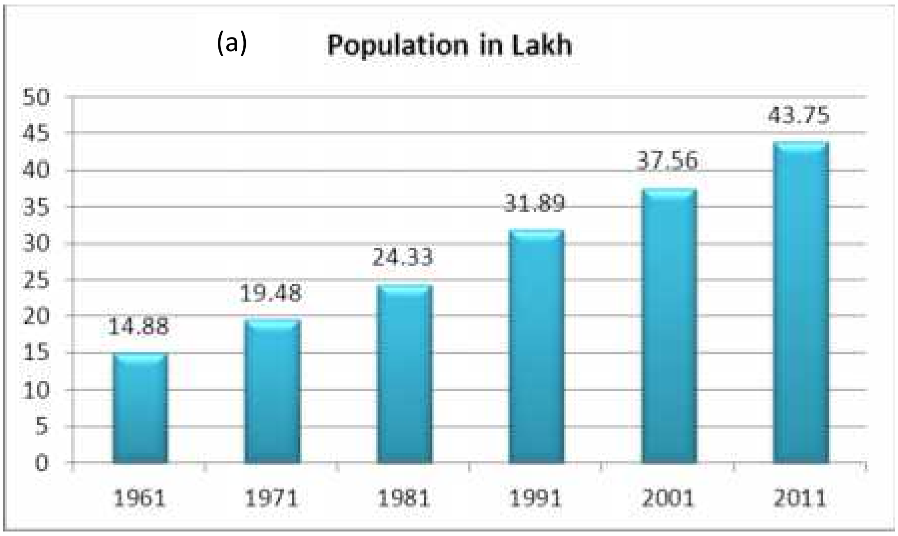
Major land use in the Sundarbans region[2], is for agriculture and homestead garden purposes, which is around 304834 ha and 41812 ha respectively and together constitute 65% of the total area under Sundarbans. The forests occupy 15% of the total area of this region. A substantial part of the Sundarbans – about 18% is classified as residual area by the Sundarban Affairs Deptt., which includes the continuous land building and destructing process in the region. The land use distribution is depicted in Figure 13.3b.

Forests: The forest area of Sundarban covers an area 4265 sq. km and is reserved for conservation purpose. It is observed that there is 5 per cent loss of forest cover in 20 years (1989 -2009)[109]. The forest area is divided into five distinct categories based on different mangrove associations:

- Deforested mangrove swamp – found mostly in the western and central parts of Sundarban;
- Dense mangrove forests – currently found only in the south – eastern part;
- Tall & dense mangroves – these are restricted to the eastern part of Sundarbans and are comprised of *Heritiera fomes*;
- Brakish water mixed *Heritiera sp.* Forests – these are rare and largely confined to the north –eastern part;

[108] Census of India, 2011.
[109] As indicated by the SAPCC Working Group Report on Sundarbans

- Palm swamps dominated by *Phoenix paludosa* – these have scattered distribution and are found through out the Sundarban forest.



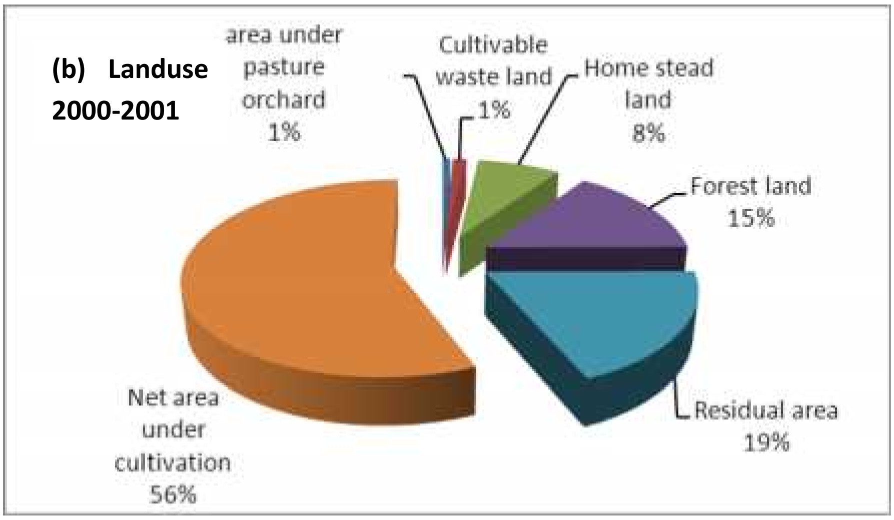


Figure 13.3: (a) Trends of population[3] and (b) Land use distribution in Sundarbans area[110]

The Sundarban, in its eastern side, has an area of 2585 km2 demarcated for conservation of Tiger, with a core zone of 1700 sq km known as the Sundarban National Park and is surrounded by a buffer zone covering 885 km2 that houses the Sajnekhali Wild Life Sanctuary, and a clear area within the forest is demarcated for preservation for gene pool. No human intervention is allowed on this side of the Sundarbans (see Table 13.1).

An additional 1680 km2 in the western side of Sundarbans, has the Lothian Wild Life Sanctuary, the Haliday Island Wild Life Sanctuary and a designated Reserved Forest. This area allows limited human intervention for extracting non timber forest products.

Biodiversity: The Sundarban ecosystem is one of the most biologically protective and taxonomically diverse ecosystems of the Indian Sub-continent. The Sundarban Mangrove forest, the mangrove swamps, and backwaters of Sundarbans form a barrier to cyclones and tropical storms originating mainly in the Bay of Bengal and to tidal surges, providing protection to a

[110] Sundarban Affairs Deptt, Govt. of West Bengal., accessed from www.sadepartmentwb.org/Distribution_of_Land.htm on 25th March 2012

Table 13.1: The Reserved area of Indian Sundarbans

Designated Areas	Zoning	Designation	Area (sq. Km.)	Remarks
Sundarban Tiger Reserve: 2585 sq. km. [Eastern side of Matla River]	Core Zone	Sundarban National Park	1700	An area of 124.4 sq km preserved as " Primitive Area" for gene pool preservation purpose.
	Buffer Zone	Sajnekhali Wild Life Sanctuary	362	
		Designated Reserve Forest	523	
Reserve Forest of South 24-Pgs : 1680 sq.km [Weastern side of Matla River]	Manipulated Zone	Lothian Wild Life Sanctuary	38	Limited human intervention allowed.
		Haliday Island Wild Life Sanctuary	6	
		Designated Reserve Forest	1579	

large part of inhabited areas inland and to the coastal fringes. The mangrove forests, mangrove swamps, and backwaters of Sundarbans form a productive and protective margin of coastal Sundarbans. The mangrove are characterised by the presence of pneumatophores, salt glands, lateral and tilt roots and crypto-viviparous germination. This unique ecosystem provides a wide range of important environmental services and due to the nutritional inputs provided by the mangroves to the adjacent coastal water, this region has become a unique nursery and breeding ground of aquatic and marine fauna such as finfish, shellfish and marine fauna.

Mangrove vegetation: Mangrove vegetation of Indian Sunderban comprises an area of 2120 square km[111]. It is one of the 19 Sub-State Sites identified in the National Biodiversity Action Plan (NBAP). According to the survey carried out by BSI in 2002, the Sundarban forest holds 61 of the 68 mangrove species found in India. These are unique vegetations vigorously growing and surviving in swampy & marshy inter tidal areas even under submergence of sea water for long hours. See Table 13.2 for the list of endemic mangrove species of Sundarbans.

Table 13.2: Endemic plant species of Sundarbans

Common Name	Scientific Name	Description
Sundari Tree	Heritiera Fomes	H. Fomes is a major timber-producing tree of sundarbans. Large Sundarban trees with 2m girth were found earlier but have been

[111] A K Raha, Indian Sunderban: An Overview, Report on Sunderban, Biosphere Reserve, West Bengal Forest Department, 2004

		heavily harvested. Now trees over 1 m in girth are no longer common. Height of H Fomes ranges from 15 to 25 m and d.b.h. from 2.5 to 38 cm depending onsite quality. It is an evergreen tree, thrives at 7.22 °C to 37.78 °C and heavy annual rainfall of 1600 mm to 5334 mm. In the Sunderbans, it is the climax species in newly formed inlands with sweet, brackish, and saline water. It is dominant in the slightly saline and moderately saline zone and thrives in a well drained soil inundated by tidal water of a low degree of salinity
Mangrove apple	Sonneratia Apetela	It is a small to medium size columnar mangrove tree, which can attain a height of about 20 m and a girth of about 2.5 m. The tree occurs on newly accreted soil in moderately to strongly saline areas and is considered as a pioneer species in ecological succession.
Sea Date/ Khadi Khajur	Phoenix Paludosa	paludosa (paludosa, Latin, swampy) or Mangrove Date Palm is a species of flowering plant in the palm family. Clustering, to 5 m high, usually forming dense thickets, the leaves are 2 to 3 m long and re-curved.

Sundarban Mangrove Forests, Sajnekhali[112]

Several key biodiversity species have become extinct or are in the verge of becoming extinct in this region. The current stress factors include Alteration in Habitats, environmental changes, biotic pressure, over exploiatation of the natural resources in the region including that of medicinal plants etc. The list of endangered species is given in Table 13.3.

Table 13.3: Endangered plants species of sundarbans

Name	Current Stresses
Amoora Cucullata	Alteration of habitat changes and environmental changes

[112] *Sourced from:* http://www.portal.gsi.gov.in/portal/page?_pageid=127,723772&_dad=portal&_schema=PORTAL&linkId=1213

Cynometra Iripa	Environmental changes
Heritieria fomes	Biotic pressure and environmental change
Intsia Bijuga	Over exploitation
Kandelia Candel	Change of Environment
Merope Angulata	Habitat Change and environmental change
Rhizophora apiculata	Exploitation due to medicinal properties
Srcolobus griffithi	Over exploitation and habitat changes
Phoenix Paludosa	It is a back mangrove species, and is therefore particularly vulnerable to coastal development and sea-level rise

Faunal Species: More than 1692 faunal species are present in this ecosystem. These comprise of faunal groups like – (i) invertebrates: Aquatic and inter – tidal invertebrates, Insects, Arachinds (ii) Vertebrates: Fish, Reptiles and amphibians, Birds & mammals. A good number these species are classified as special status under the Indian Wildlife Protection Act (1998) and are classified as rare and endangered.

The most noted species of the wild life of the region are Royal Bengal Tiger, Spotted Deer, Wild Boar and Estuarine Crocodiles. These are on the CITES list, or are classified as rare & endangered species. The endangered list also includes River Terrapin, Ganges & Irawady Dolphins and varieties of migrants & resident avifauna. One of the living fossils viz. Horse Shoe Crab inhabits in this region. At least three species of marine turtle and several species of cetaceans exist in this coastal habitat.

Figure 13.4: Typical fauna of of Sundarbans- Royal Bengal Tiger (Panthers Tigris), Estuarine Crocodile (Crocodilus porosus) and Birds (Sea gulls)

Algae, Bacteria, Fungi, Plankton and Micro-Fauna: There are several species of these microbial elements in the Sundarban estuary with the support of ocean current, water temperature, and salinity, biotic & abiotic substrata in this ecosystem. These micro biological elements are important in their contribution to high primary productivity and are crucial components of the ecosystem. These also maintain the balance of food chain. However the populations and distribution of Phytoplankton & Zooplankton are very sensitive to seasonal variations and on the trends of fluctuations in environmental parameters.

Livelihood profile: As per the 2001 census, number of agriculture cultivators are 24.37% of the total Sundarban population, with agricultural land less labourers comprising 36.35% of the population. Household industries and artisans comprise of 4.86% of the population and the rest practice miscellaneous livelihoods such as fishery, natural resource collectos, some professionals and some provide various services. There is seasonal migration of substantial population to the other parts of the country seeking employment.

Agriculture: As per government statistics, in 2009, the availaibility of agricultural land in the Sundarbans was around 1691.246 sq km[113]. 61% of the area is in the low lying areas, the medium & upland areas are 26% & 11% respectively of the total area available for cultivation.

The agricultural system of the region is centered on two main cultivating seasons. In the *khariff* or monsoon season between June to September and *aman* paddy is planted and in the post monsoon period in the months of November to December it is harvested. In addition, some high value vegetables like ladies finger, ridge gourd, bitter gourd, beans, snake gourd, and water melons etc are grown in uplands and *AILs* (field bundhs). In the *rabi season* between November to June paddy is cultivated in irrigated condition which extends only to 12% of the total cultivated area. In this season pulse like *khesari & moong* and oil seeds like sesame, mustard and sunflower and some vegetables are also grown.

Human Health: People of Sundarbans are primarily affected by water and vector borne diseases while air borne diseases like Acute Respiratory Infections are a perpetual occurrence. Chronic malnutrition has also been observed among the children under the age of 5 year & women in Sundarban living in extreme poverty. The diarrhoeal prevalence peaks when cyclones strike. The cyclones also bring exacerbate the occurrence of water-borne diseases (e.g., gastro-enteric diseases) as people have no choice but to consume contaminated water. In addition, snake bites, accident injuries, skin related problems, and vector-borne diseases (such as, malaria)[7].

The public health facilities include 2 Sub-divisional, 9 Rural Hospitals (RH), 10 Block Primary Health Centers (BPHCs), and 47 Primary Health Centers (PHCs). The Block level facility (BPHC/RH), in addition to playing a role of a referral unit, acts as a hub of all primary health care activities within a block.

The sub-centers are adequate in number if one goes by the usual standard (5000 population per sub-centre), but the number of PHCs, are inadequate by the same standard (30,000 per PHC). The inadequacy is more prominent in South Sundarbans especially in some blocks (Gosaba, Canning I and II, Patharpratima, and Kakdwip)[114]. An inter regional disparity has been analysed

[113] http://www.thehindubusinessline.com/industry-and-economy/agri-biz/article2950858.ece uplorded on March 1, 2012, based on the CSE report brought out by CSE; accessed on 25th March 2012

[114] Barun Kamjilal, Papya Guha Majumdar, Moumita Mukherjee, Swadhin Mondal, Debjani Burman, Sneha Singh and Arnab Mandal; 2010. Health care in the Sundarbans India- Challaenges and plan for a better future. Accessed from http://www.futurehealthsystems.org/publications/health-care-in-the-sundarbans-india-challenges-and-plan-for.html; 25th March 2012.

in the HUmna Development Report of West Bengal (2009)[115], which clearly indicates the lower level of infrastructure including patient care in the Island area with respect to mainland areas of Sundarbans. See Table 13.4.

Table 13.4: A comparison of primary health care in Sundarban island blocks with respect to other blocks[8].

Provisions for primary health care (Rural Hospitals + Block Primary Health Centres + Primary Health Centres)	Island blocks around forest boundary	Other Sundarban Blocks
Number of beds per thousand population	0.232	0.299
Number of Medical Officers per thousand population	0.030	0.052
Number of Health Assistants (male + female) per thousand population	0.227	0.285

Access to Energy: The electricity supply from all sources (viz. Grid – Power, Renewable Energy Sources, Solar Home Lighting Systems and Diesel Generators) in Sundarbans is estimated to 262.8 million units/ year. Around 3.5% of total supply is contributed by the renewable source of energy. As of 2010, 1.20 lakh hhs have been electrified The details are shown below in Table 13.5. The per capita electricity consumption in Sundarbans is much lower compared to that of India and West Bengal respectively, it is 58,4 KWh/ year as compared to 380.61 KWh/year in West Bengal and 717.0 KWh/ year at India level. The increase in demand in 2020 is expected to be 7.5 to 15 times that of the present demand.

Table 13.5: Status of Electrification of households in Sundarbans (in lakhs)

Districts	No. of HHs.	No. of HH Electrified	No. of BPL HHs
North 24 – Pgs.	2.04	0.53	0.87
South 24-Pgs.	4.90	0.67	3.36
Total for Sundarban	6.94	1.20	4.23

Power Department in collaboration with Sundarban Affairs Department has taken up programme for extension of grid power to 121 non – electrified mouzas of Pathar Prtaima, Gosaba, Mathurapur –II , & Kultali Blocks crossing the rivers through towers & rail poles. The works for transporting grid power from Kakdwip to Sagar crossing Muriganaga River through towers are almost complete. The project for extension of grid power to 100% house holds in Sagar island ahs been sanctioned under The World Bank assisted Integrated Coastal Zone Management Project (ICZMP). Extension of grid power to the non-electrified mouzas of Sundarbans have been taken up through RGGVY fund but the progress of work is considered to be very slow.

Current Key Concerns of the Indian Sundarbans Region

[115] Human Development Report – West Bengal 2009. Accessed from wbplan.gov.in/HumanDev/DHDR/24%20pgsSouth/Chapter%2009.pdf, 25th March 2012

Recurrent Cyclones & storms: The cyclonic depressions in the Indian ocean, bringing in high winds, heavy rainfall and strong tidal surge, occur between May to November (see Figure 13.5a). Though the number of depressions are the highest in the month of August, maximum number of them develop into cyclonic storm in the month of October, and the number of severe

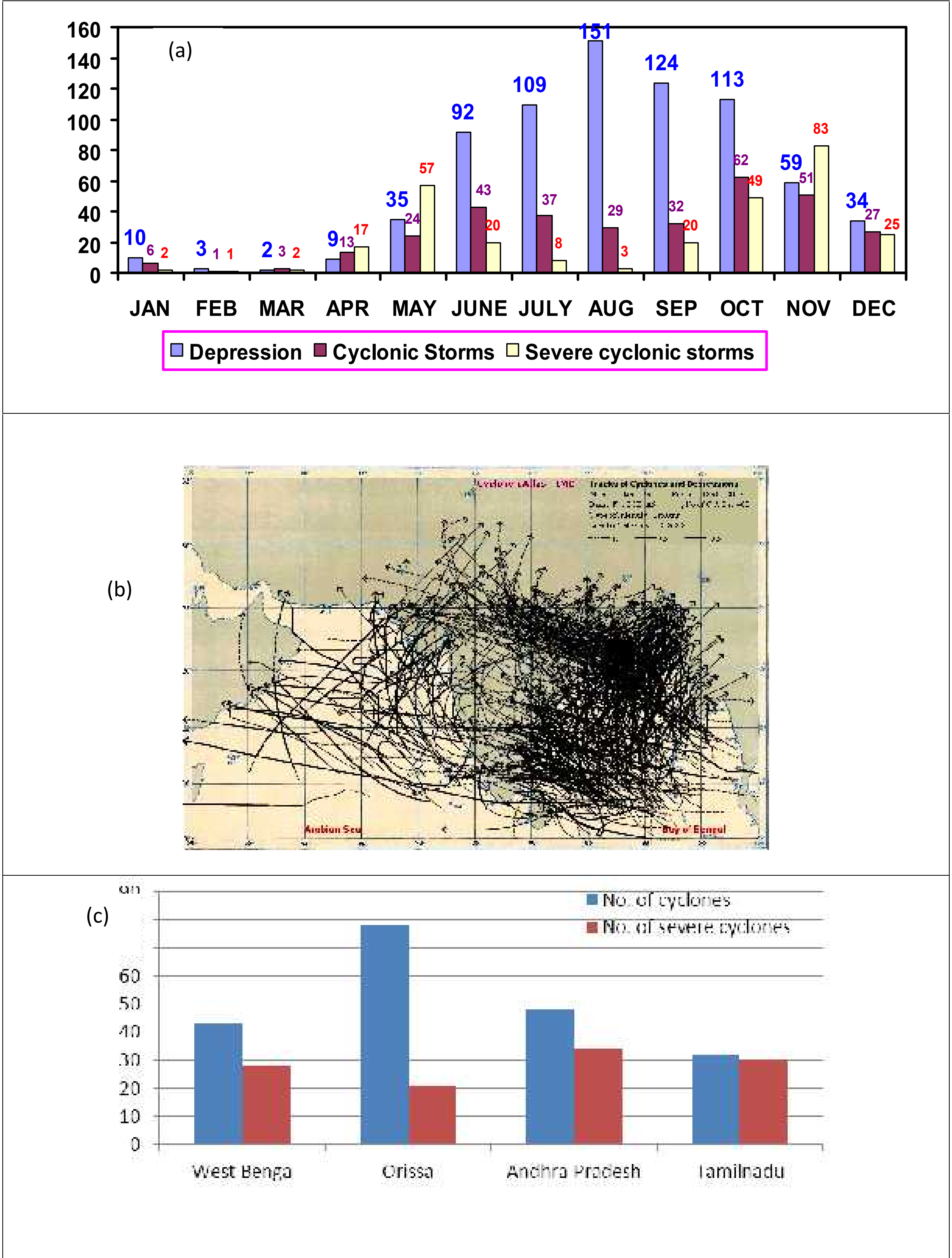


Figure 13.5: (a) Monthly disturbance of Cyclonic disturbances between 1891-2007 over the Indian Ocean; (b) Cyclonic storm tracks in Bay of Bengal between 1891-2007; (c) Cyclonic land

falls between 1891-2006 in Bay of Bengal.

storms formed were 284 in number, out of which 94 intensified up to the stage of Severe Cyclonic storms (33%) in

Severe Cyclonic storms (57%). The intensification of the systems is stronger during the epoch II than the epoch I even though there is a decrease in the total number of cyclonic storms over Bay of Bengal from epoch I to epoch II (see Figure 13.5).

Further examination of the data sets on the decadal scale showed that 35 cyclonic storms formed inthe Bay of Bengal during the decade 1981-1990 out of which 22 (63%) intensified in to Severe Cyclonic Storms and during the decade 2001-2010, 32 cyclonic storms formed in the Bay of Bengal out of which only 11 (34%) intensified in to Severe Cyclonic Storms. This general analysis points towards the fact that the cyclonic storm hitting the Sundarbans area have increase in intensity between 1951 and 2010. The increase in intensity is attributed to the increase in Sea Surface temperature (see Figure 13.6).

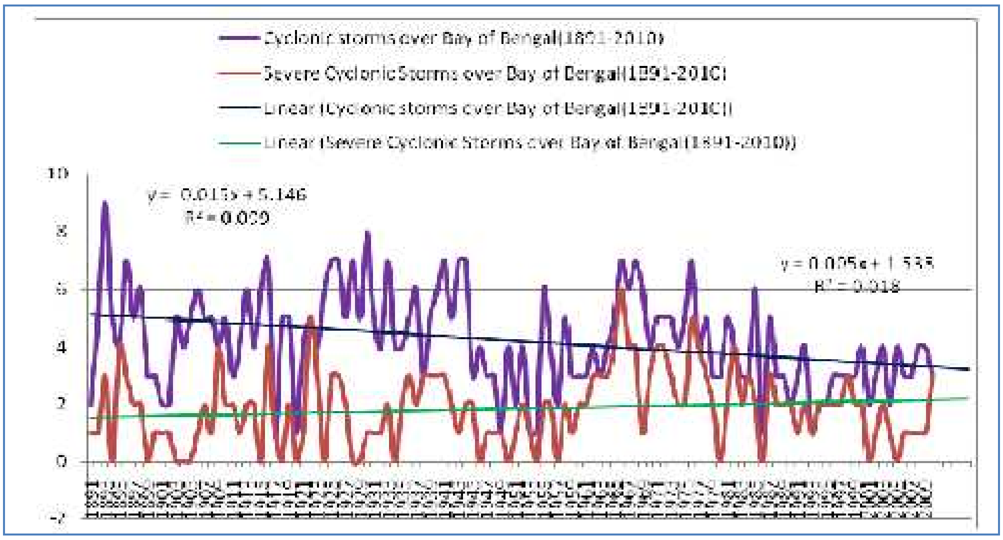


Figure 12.6: Trends of cyclonic disturbances in the Bay of Bengal between 1891-2010[3].

cyclonic storms are the highest in the month of November[116]. The tracks of storms in the Bay of Bengal region between 1891-2007, indicate a substantial number of them hitting the

Indian Sundarbans area[1] (Figure 13.4b). Hatawar et al.[117], have observed that about 44 cyclonic disturbances have crossed the Sundarbans area between 1891 and 2006, of which 35 were severe cyclonic storms (Figure 12.4c). In some cases when the cyclonic events having wind force more than 100 km per hr they are synchronized with the high tides, the waves influenced

[116] Recent and Current Activities of the RSMC New Delhi. 2009. Paper submitted in the sixth Tropical CycloneRSMC/TSWCs, technical Coordination Meeting, Brisbane, Australia, 2-5th Nov 2009. WMO, TCM-V /Doc. 3.2 (3) (19.X.2009), Item 3.2.

[117] Hatawar et al., Challenges in Tropical cyclone forecasting, 2010. Accessed from: www.nidm.gov.in/idmc2/PDF/Presentations/Cyclone/Pres8.pdf

by storm surge hit the river embankments causing breaches and flash flood due to sea water ingress.

Increasing Intensity of Cyclones: An analysis in general of the cyclonic storms occurring in Bay of Bengal by Setharaman, 2011[118] for the period 1891-2010 that the total number of cyclonic

Recurrent breaching of the Embankment : Along the Sundarban Delta the tidal amplitude ranges between 3.7 to 5.0m above mean sea level. The higher tidal amplitude occurs in monsoon months mostly in August – September. Due to progressive sedimentation & shallowing of channels, the height of tidal amplitude is become as high as 6m along the coast line and further inland it increases to around 7m.

Surface waves in this coastal area are mainly due to wind action. Waves become destructive during cyclonic storm. When the Cyclonic incidences coincide with tides, wave height rises over 5 m and above the mean sea level.

Due to heavy loads of siltation, water levels in many embanked creeks remain at least two metres above the adjoining flood plains during high tides. The tidal waves often breach the embankment and the severity of breaching and extent of damage increases when cyclones strike. The storm surges during cyclones have taller wave height and as a result other than breaching the embankment, they also ride over it and enter the plains flooding large areas, creating water logging and making the soil more saline than its natural state. For example, during Cyclone Aila in 2009, a 400 km stretch of embankment was breached and the waves crossd over the height of the embankment at many other places and entered the flood plains. The sea water got logged in the plains and more than two million people were marooned for several days affecting not only agriculture but also drinking water supply. Most of the thatched houses were damaged. The farmland became non-productive due to salt water incursion in the soils.

Breaching of the Embankment in Sonakhali Sundarbans during Cyclone Aila[119]

[118] K Seetharaman, 2011. Published in Extended Abstract form in the proceedings of the workshop on - Climatology and intensification of Bay of Bengal Cyclonic storms; National Conference on Bay of Bengal Tropical Cyclone Experiment (BOBTEX); New Delhi 1-2 Nov, 2011.. Published by Cyclone Warning Div., India Meteorological Deptt., Mausam Bhawan, New Delhi.

Changing Water mass properties in the eastern and western sectors of the Sundarbans[120]: Studies carried out over a period of 27 yrs indicate changes in the properties of water in and around Sundarbans, which is also one of the key drivers towards the changing biodiversity in the area. A description of these changes are as follows:

Water Temperature: Between 1980 and 2007, the waters in the Sundarbans is gradually warming up at an average rate of 0.5°C per decade, with warming being more in the western parts of Sundarban region than in the eastern parts. The warming observed in Sundarban waters is higher than the observed global sea surface temperature warming of 0.06°C per decade and the warming of the Indian ocean at the rate of of 0.2°C per decade. See Figure 13.7.

The warming of the sea in any case has implications on aquatic life, as the CO_2 escapes with warming. However, rapid increase in sea surface temperature further compounds the effect, especially in the Sundarbans area, where the impact is likely to be on the nutrient rich waters affecting both the mangroves and the other acquatic fauna that thrives on this nutrient rich waters such as fish.

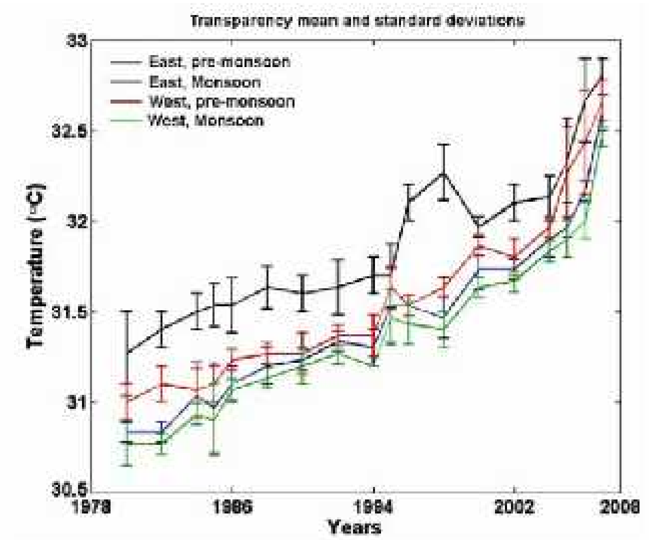


Figure 13.7: Rising Surface Water Temperature along the Sundarbans coast

PH value of Water: Further, the water in the western sector of the Sundarbans shows a higher PH with respect to the water in the Eastern side of the region. This indicates influx of fresh water in the western river systems of Hoogly and Murigamnga flowing through the Sundarbans. These rivers are a continnum of the Ganges and the the fresh water in these river systems is

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[119] Courtsy: Kaustav De, Downloaded from public website https://plus.google.com/photos/103953505186456931066/albums/5343481724186861377?banner=pwa&gpsrc=pwrd1#photos/103953505186456931066/albums/5343481724186861377/5343482291007303378

[120] Source: Mitra Abhijit Mita, Avijit Gangopadhy, Anumeha Deb, Andre K Schmidt, and Kakoli Banerjee. 2009. Observed changes in Water Mass Properties In the Indian sundarbans (North western Bay of Bengal) during1980-2007. Current Science, vol 97, no. 10, Novermber 25, 2009.

attributed to influx of fresh water in the ganges due to recession of the Gangotri glacier[121] from which it originates.

Dissolved Oxygen: An analysis of the Dissolved oxygen in the two regions, indicate that in the eastern sector the DO has increased by +0.3ppm/decade and in the eastern sector the DO has decreased by -0.4ppm/decade. Increase in DO is attributed to fresh water influx in the western rivers, and decrease in DO in the western rivers are due to increase in salinity due to siltation, mixing with ocean water and possibly due to high evaporation rates as the surface air temperature increasing. Similarly the transparency of the eastern region waters has increased wrt the Western region.
In conclusion, the western region waters have an improved in water quality than its counter part in the eastern region of Sundarbans and the trend continues to increase in both the sectors.

High dependence on natural resource based livelihoods **:** The primary occupation of 43.7 lkah population in Sundarbans is mono crop agriculture that contributes to 77.55% of the local economy directly or indirectly. Other than crop husbandry, people of Sundarban also have fishing as a livelihood and collect NTFPs from forests.

Agriculture: According to the West Bengal government, in 2009, the agricultural area has shrunk between 2002 and 2009 from 2149.615 sq km to 1691.246 sq km. The average paddy yield is around 2,037 tons/ha in this area between 2009-10, and the cropping intensity is very low, ranging between 1.5 to 2 tons/ha against the national average of 3.28 ha. The low intensity of cropping is because (i) only mono cropping of rice is practiced in the Kharif season and in the rabi season horticultural crops are grown; (ii) also because, agriculture is mainly rainfed, with only 12% of the cropped area being irrigated through rainfed ponds, tanks and canals; and (iii) because of high levels of salinity of the soils due to high tides, cyclones and storm surges, and problems of water stagnation, even beyond monsoon seasons at times. With continuous increase in population, agriculture production in the region is not able to meet demand. Frequent damage to property and crop failure due to cyclones and thunderstorms has rendered a large population poverty ridden. As a result, high levels of migration to cities is reported from here.

One of the very few Rainwater harvested ponds in Sundarbans

Non Timber Forest Products (NTFPs): is an essential components of the livelihood of the people living within the Sundarbans mangrove area. A study carries out by Singh et al.[122], concludes that about 79% of the livelihood earnings of the people from this region comes from NTFP. The NTFPs include tannin bark from of most Sundarban species like *Ceriops decandra, Ceriops*

[121] As per the reports of the Working Group on Himalayan Glaciers of the International Commission for Snow and Ice (ICSI, 1999) and the World Wide Fund for Nature Report, Climate Change In Sundarbans, 2007
[122] Anshu Singh, Prodyut Bhattacharya, Pradeep Vyas and Sarvashish Roy; 2010.Contribution of NTFPs in the livelihood of Mangrove forest dwellers of Sundarbans, Journal of Human Ecology, 29 (3), 191-200.

myrobalans, Phoenix paludosa which yield around 30-42% tannin; *Nypa fruticans* (Golpata), natural honey from *Apis dorsata*, cultured apiary honey and bee wax from *Apis indica*; fuel wood and small poles and boles; fishes, prawn, crab, shrimps; and lime (manufactured from jorgran, kastura and jhinuk). However, as many of the mangrove species are becoming endangered they are falling under the perview of conservation and therefore their extraction is also getting reduced, affecting the earnings of the people.

Fisheries: A number of individual, groups of commercial fishermen and MNCs are collecting large-scale commercial catch from the coastal, estuarine and deep sea zone of Sundarbans throughout the year. Fisheries is done through collection of prawn post larvae; acqua-culture in coastal swamps; Intensive fresh water mono aquaculture of shrimp is practiced in some parts especially at the estuarine mouth where salinity is lowered by fresh water discharge through rivers 'paddy cum fish cultivation; and by commercial fishing in estuaries and deep sea zones.

Large scale mechanization, has boosted export-based fishing economy, but this is also degrading the sensitive aqua-mangrove ecosystem of Sundarbans due to unsustainable practices. Intensive prawn culture in paddy cum fish areas is endangering the indigenous varieties of fish such as *Vada, Khalisa, Mourala, Nados, Chanda, Khaira*, etc. Further, frequent oil leakage and regular washing of fishing vessels is causing water pollution near local sand heads leading to lack of fish gathering in and around these areas [123].

Box 13.2: Possibility of extracting medicinal plants from the mangroves

Mangroves also have medicinal properties (Lakshmanan et al., 1984; Naskar et al., 2002). Table below demonstrate some basic medicinal qualities of selected mangrove plants of Sundarban. If properly cultivated and processed, these can fetch significant livelihood opportunities

Name of the Plant	Common medicinal uses
Tamorix diocia	Tonic, Skin diseases
Tamarix gallica	Astringent in Dysentry
Thespia Lampu	Seed powder in Bronchitis
Derris Indica	Root as substitute for quinine
Cerops Tagal	Asthama and snake bite
Acanthus ilicifolus	Roots for blood pressure
Rhizophora apiculata	Bark in Diarrhoea
Derris Trifoliata	Antispasmodic and stimulant

Source:PDebajit Dutta, R N Chattopadhya and Shovik deb, 2011. Prospective livelihood opportunities from the Mangroves of Sundarban, India. 2011. Research journal of Environmental Sciences 5 (6): 536-543. Accessed from http://scialert.net/qredirect.php?doi=rjes.2011.536.543&linkid=pdf

[123] Mahua Das, 2007. Impact of Commercial Coastal Fishing on the Environment of Sundarbans for Sustainable Development; Asian Fisheries Science 22 (2009): 157-167; accessed from www.asianfisheriessociety.org on 25th March 2012

Concerns of the Health Sector in Sundarbans

Inaccessibility of health services : The difficult terrain and isolation denies the people of Sundarbans quick access not only to the nearby facilities but also to the facilities out side this region. Such inaccessibility to health facilities have resulted in the obvious emergence of quacks and RMPs.

Poor socio – economic indicators and environmental conditions resulting in perpetual morbidity and malnutrition : Inadequate & contaminated water supply, lack of sanitation and low level hygienic condition cause diarrhoeal diseases, dysentery, jaundice and worm infection. Sundarbans is experiencing a rise in vector borne diseases particularly Malaria. Kalazar and Encephalitis are also found in some blocks which are possibly a result of migration. There are instances of other diseases like goiter.

Occupational health hazards *:* Majority of the people of Sundrabans are dependent on natural based livelihoods and occupation which lead to different health hazards Women engaged in shrimp larvae collection in the rivers suffer from dermatological diseases and gynecological problems and urinary tract infections due to long time immersion in saline water. The farmers, fishers and forest product collectors are under constant threat of animal attacks particularly snake, crocodile, tiger, shark , etc.

Key Climate Change Concerns for Sundarbans

Sundarbans within the Indian region is a special area, as not only the ongoing climate change in terms of temperature and increase and precipitation changes is likely to impact its physical and man made systems, but the vulnerability of these systems is likely to be heightened due to the added impacts of increase in cyclone strengths and sea level rise. Some of the key climate change concerns are highlighted in the box below, and the situations for which adaptation will be required including the adaptation strategies are discussed below.

Box 12.3: Observed and projected changes of Climate Change in Sundarbans in 2050s with respect to base line (1960-2005)*

- The maximum temperature has decreased by -0.50^{o}C between 1960-2005
- The minimum temperature has risen by 1^{o}C within the same period
- No change in total annual rainfall
- Increase in heavy precipitation events
- Winters are becoming drier
- Frequency of cyclonic disturbances have decreased, but intensity has increased
- Annual average minimum temperature is projected to rise by 1.8 to 2.0^{o}C in the coastal region of WB
- The maximum temperature will also rise by 3.6-3.8^{o}C between the same period
- Precipitation to rise in the monsoon period by 1.25 times, nominally decrease in Oct-Dec and will not change in Jan-Feb
- The severity of the cyclones likely to increase with increase in sea surface temperature

Impacts on Mangroves Flora: Because of their location at the interface between land and sea, mangroves are likely to be one of the first ecosystems to be affected by global changes. As the Mangrove systems are very specialized, and may live close to their tolerance limits, they are particularly sensitive to minor variation in hydrological or tidal regimes[124]. Reduced runoff in the eastern region of the Sundarbans would increasingly produce higher salinity and greater seawater-sulfate concentrations. Both would decrease mangrove production[125]. The most important effects, however, would come from rising sea levels, but responses will vary among locations and will depend on the local rate of the rise and the availability of sediment to support reestablishment of the mangroves[126],[127],[128].

At continuous submergence in higher water depth, the plants would have significantly lower rates of photosynthesis and growth, be shorter and narrower, have fewer branches and leaves, and more acid-sulfide in their soils. Increased mangrove growth rates predicted for increasing atmospheric CO2 may be offset by decreased growth resulting from changes in tidal regimes.

Impacts on Mangrove Fauna: The mangrove-associated fauna would be affected both directly by climatic changes and indirectly by changes in the mangroves[129]. Species that are tolerant of increasing temperatures (e.g., fish, gastropods, mangrove crabs and other crustaceans) may adjust rapidly to the changes. In contrast, soft-bodied animals and bivalve mollusks would be very sensitive to higher temperatures. Desiccation that would accompany increasing temperatures would harm many marine species associated with mangroves[130]. For mangrove-dependent species, however, the most serious consequences of a changing climate would likely be the loss of habitat as the mangrove forests declined.

Increase in incidences morbidity and mortality amongst the human population: The increase might be due to water borne diseases as water is likely to become more unpotable. Similarly increase in intensity of cyclones is likely to cause more injuries and deaths. Water logged conditions also might increase incidences of dengue in urban centres of Sundarbans and lead to increase in malaria vectors in the mangrove forests, thereby increasing incidences.

Impact on agriculture: Higher temperatures may lower yields which already are not enough for the burgeoning population of the region. Also with more and more area getting inundated by cyclones and higher storm surges, agriculture is likely to be affected in the flood plains of Sundarban as the salinity in the soil rises (the recent example being the imoacts during cyclone Aila).

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[124] Blasco, F., Saenger, P. and Janodet, E. (1996). Mangroves as indicators of coastal change. Catena 27 (3-4) 167-178.

[125] Snedaker, S.C. (1995). Mangroves and climate change in the Florida and Caribbean region: Scenarios and hypotheses. *Hydrobiologia* **295** (1-3), 43-49.

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[127] Parkinson, R.W., Delaune, R.D. and White, J.R. (1994). Holocene sea-level rise and the fate of mangrove forests within the wider Caribbean region. Journal of Coastal Research 10, 1077-1086.

[128] Woodroffe, C.D. (1999). Response of mangrove shorelines to sea level change. Tropics 8 (3), 159-177.

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[130] Kjerfve, B. and Macintosh, D.J. (1997). Climage change impacts on mangrove ecosystems. In " Mangrove Ecosystem Studies in Latin America and Africa" (B. Kjerfve, L.D. Lacerda and S. Diop, eds), pp. 1-7. UNESCO, Paris

Availability of potable water: With the eastern region of the Sundarbans receiving sweet water from the ganges, and the western region becoming more and more saline, availability of potable water in the long run is likely to be an issue for both the human settlements and wild habitats in the western region of the Sundarbans. Further with increase in intensity of cyclones, potable water stored in ponds and dighis are likely to be impacted even in the eastern region for longer periods of time as volume water incursion will be higher as higher heights of storm surgs enter inland covering larger areas.

Adaptation Strategies

Protection against Increase in intensity of cyclones: The cyclones are projected to be come less in number with respect to their current frequency, but their severity will most likely intensify, meaning that that wave heights will increase, making ingress of sea water **deeper** inland. Therefore the entire Sundarban region and all its sectors are highly vulnerable to climate change. Increase in intensity of cyclone will mean, devastation of human habitats, in accessibility to potable water, loss in communication and transport. It will also lead to adverse and may be irreversible damages to the flora and fauna, as the sea water ingresses inside the creeks and inland, leading to high levels of salt ingression.

The Adaptation Action would include:

i. Undertaking a study to generate low , medium and high scenarios of impacts of climate change on cyclones, for 2030s, 2050s, and 2080s to enable informed decision making and implementation of measures towards adaptation. The projections will give the likely return periods, trace the paths of cyclones and storm surges to track the likelihood of land fall along the Sundarban coast, the maximum and the minimum heights of the sea surges/waves during cyclones even when they ride over high tides, and an assessment of the spatial extent to which the waves can carry salt water inland.
ii. Identify the level of tolerance of the various existing mangrove species to the different levels of projected salinity and flood water depth.
iii. Identify, the type and density of the mangroves required to act successfully as the 1st level of defense and accordingly, the mangrove plantation can be taken over.
iv. Identify the endangered species of fauna and building up strategies for conservation & protection of faunal species
v. Construct/retrofit the embankment along the sea as well as along the rivers based on the likely return periods and maximum heights of storm surges that can occur
vi. Based on the studies, scientifically raise the existing houses in vulnerable areas on stilts based on the level of flood water height likely to ingress in the future. Also Identify safe areas, and build/strengthen cyclone shelters for people as well as livestock.
vii. Early warning system, though in place, does not seem to be effective, as witnessed during cyclone Aila in 2009. Therefore mobilise communities to take action rapidly and cyclone proof themselves when early warnings are sounded by authorities vis a vis moving people and livestock and their valuables to safer places.
viii. Strengthen communication – roads and telephony
ix. Identify the key sectors of livelihoods, building up strategies for sustainable use of natural resources, construction of infrastructure to support sustainable livelihoods, insurance coverage to the stakeholders of key livelihood sectors.

x. Improvement of general health care services ensuring coverage of cent percent population, building up sources for sustainable & safe drinking water to every one.
xi. Rehabilitation strategies and package for post disaster renovation supported with social services & alternative livelihoods

Total Cost: 12th plan- Rs. 1710.00 Cr; 13th Plan- Rs 1583.00 Cr

Protect agriculture productivity and livelihoods

- Height and quality of the embank plays an important role in protecting agriculture in the region from additional salinity in soil due to projections of increasing intensity of cyclones
- Introduce thermal resistant and salt tolerant rice cultivars
- Promote commercial level coconut plantations in saline areas
- Promote horticulture vegetable crops
- Provide access to markets through construction of roads
- Provide storage , marketing & processing facilities
- Provide crop insurance for cereals & commercial / plantation crops

Cost: Rs 100.00 Cr

Promote alternate livelihood opportunities: (i) Inland and marine fisheries can be further promoted as an alternative livelihood for the population, in addition to cropping. A fishery policy may be formulated centering around conservation vis a vis climate change impacts. Early warning systems for fish catch availability in marine areas may be provided through modeling – therefore modeling capacity to map fish catch on a real time basis needs to be developed. Provide insurance to fishermen against calamities.
(ii) Promote animal husbandry & poultry/ duckery as alternative livelihood with market support & insurance coverage.

Cost
12th Plan - Rs. 200.00 Cr
13th Plan – Rs. 200.00 cr

Enhance the accessibility to drinking water: This would mean supplying piped water to all households. This can be done by drawing water from the western rivers in Sundarbans as they are likely to have more fresh water in the near future. Also the potable water supply can be augmented through more exploitation of ground water in the areas. Further, rain water harvesting of water and storing it in overhead tanks at higher heights can be thought of as an additional option to keep water clean and potable. Introduction of roof-top rain water harvesting in community buildings be introduced.

Cost:
12th Plan-Cover all the gap areas in 12th Plan. Cost- Rs.1000.00 Cr
13th Plan- Fore maintenance in 13th plan. Cost-Rs 300.00 Cr

Improve accessibility to health facilities: Bridge the existing health infrastructure and health service delivery gaps. Communise health service delivery. Develop telemedicine facilities. Develop rapid transport for critically injured – by pressing in helicopter services. Develop disaster preparedness to abate disease outbreaks and undertake regular drills.

Cost:
12th Plan: Rs 200.00 Cr (Identification of gaps, process of communisation, and development of disaster risk reduction plans have to start in 12th plan)
13th Plan: Continue with the activities. Cost- Rs 100.00 Cr

Conserve biodiversity: The ongoing policies and actions of the Forest Department need to go on with stricter pursuance of regulations. Further research may be launched to understand the nature of impacts of climate change on Mangroves in terms of its floral and faunal biodiversity, to plan for afforestation measures and conservation of fauna as per the dictates of the changing climate scenarios, which can be implemented in the 13th plan.

Cost:

12th Plan: Rs 5.00 Cr – research component
13th Plan: Rs. 100.00 Cr - Implementation of afforestation and conservation of fauna activities

Total Cost: 12th plan- Rs. 1710.00 Cr; 13th Plan- Rs 1583.00 Cr

See Table 20, Annexure 1 for details of strategies, actions, time lines and budgets for Sundarbans

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Annexure 1

Table 1: Water Sector

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
A. Hill Region				
1. Rain water harvesting along the hill slopes	IWRD WRIDD SWID Panchayt dept. Agriculture Deptt. Forest Deptt	i. Identification of natural aquifers in the region ii. Identify the stretches of the hills where the trenches can be dug up to recharge the aquifers through gravity flow iii. Dig up of staggered trenches with hedge row iv. Undertake gully plugging v. Identify forest areas through which recharge of streams can happen vi. Plants trees in these head of the water shed	Rs.300.00 Cr	Rs.300.00 Cr
2. Development of reservoirs intercepting River Jaldakha, Manas, Sankosh and other rivulets for transfer of water from Surplus Basin to Deficit Basin	IWRD	i. Identification of rivers and rivulets for transfer of their water to reservoirs ii. Construction of reservoirs	Rs.75.00 Cr Study and 25% to 50be completed in 12th plan	Rs.150.00 Cr 50% to be completed in 13th plan
3. Construct check dams for harnessing surface water	WRIDD IWRD Panchyaet	i. Examine the feasibility of construction of check dams ii. Construct the check dams	Cover 5 km Rs. 250.00 Cr	Cover 5km Rs. 500.00 Cr
4.Increase water storage capacity at household/ community and village levels	PHE WRIDD, Panchayet department & Local bodies	i. Identify the areas where drinking water still has to be fetched from more than 1/2 a km ii. Identify the feasibility of constructing overhead or below ground storage tanks for rain water including Control unit, inspection pit, recharge chamber, gravity head recharge well (40x50x341	3.00 lkah sq m Rs. 60.00 Cr	3.82 lakh sq m Rs. 76.40 Cr

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
		Blocks		
5. Repairing, renovating and restoring existing water bodies	WRIDD	i. 20 ha CCA	Rs. 90.00 Cr	Rs. 60.00 Cr
6. Assessment of water flow in the Teesta Barrage in the climate change context and appropriate actions to be taken to improve water inflow	IWRD	1. Scientific study 2, Develop steps to improve inflow into the barrage	Rs. 2.00 Cr	Rs. 2.00 Cr
B. Alluvial Zone				
1. Increase the reservoir storage potential of existing major irrigation projects	IWRD .	i. Removal of siltation in the reservoirs ii. blocking leakages in the reservoirs iii. Lining the sides of the canal system	Rs.250.00 Cr	Rs. 350.00 Cr
2. Recycling of waste water to reuse water for operations in the thermal power plants and in steel plants	NTPC SAIL	i. Assessment of waste water that can be recycled ii. Establishing recycling units	To be absorbed within the budgets of NTPC and SAIL	To be absorbed within the budgets of NTPC and SAIL
3. Limit extraction of ground water for limiting arsenic contamination - Formation region specific centralised ground water extraction units	WRIDD SWID IWRD Agriculture Department Panchayet Department	i. identification of deep aquifers ii. Identification of recharge zones iii. Creation of centralized ground water extraction and recharge units iv. Creating distribution systems of this water	i. Rs 1.00 Cr ii. Rs. 1.00 Cr iii. Rs. 50.00 Cr (50% of the units installed) iv. Rs. 50.00 Cr (laying pipeline)	- - iii. Rs. 50.00 Cr (rest 50% of the units installed) iv. Rs. 50.00 Cr (laying pipelines for rest of the 50%)

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
4. Creation of surface water based irrigation schemes - lift irrigation etc)		i. Identifying feasible areas and required water flow ii Create facility for lifting water up and distribution to the fields ii. Maintaining the same through public and community partnerships	50 Units for 20 ha each Rs.50.00 Cr	50 units for 20 ha each Rs.50.00 Cr
5. Encouraging rainwater harvesting in ponds in farmers fields - community ponds for small and medium farmers can be encouraged further		i. Formation of groups to form water cooperatives that would look after ponds created in fallow areas and will look after the upkeep of the water structure ii. Educating the people on the appropriate structure that needs to be maintained	Rs.25.00 Cr (25 lakh irrigation facilities)	Rs.25.00 Cr (25 Lakh Facilities)
6. Enhance artificial Recharge activities in over exploited ground water areas (critical Blocks)	WRIDD	i. Build Percolation tanks iii. Contour Bandhs iv. Create subsurface dykes v. RCC Ring wells	i. 500 ha; Rs. 150.00 Cr ii. 25 km; rs. 25.00 Cr iii. 2km, 5 .00 Cr iv. 2500 no.s,; 10.00 Cr	i. 500 ha; Rs. 150.00 Cr ii. 25 km; rs. 25.00 Cr iii. 2km, 5 .00 Cr iv. 2500 no.s,; 10.00 Cr
7. Resuscitation of Derelict channel with provision of sluice gates for storing rain water	IWRD	Activities to be further listed	Rs.100 Cr	Rs. 200 Cr
8. Abatement of floods		i.Re-excavation of existing drainage channel ii. Construction of new drainage channels	Rs. 200.00 Cr	Rs. 200.00 Cr
9. Surface water treatment plants		15 schemes each in 12th and 13th plan	Rs.200.00 Cr	Rs.200.00 Cr
10. Schemes for removing arsenic and other heavy metals from water		25 schemes to be completed within 12th and 13th plan respectively	Rs.37.50 Cr	Rs. 37.50 Cr
C. Red and Laterite Zone				

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
1. Undertake special programmes for planting forest trees or fruit plantations as appropriate to increase the run off infiltration ratio in identified regions	Department of Forests Department of Horticulture	ii. Initiate afforestation process through joint forest management iii. Department of Horticulture can have a joint initiative with people, after addition land is identified for plantation which will be over and above the existing plantation areas	Rs. 10.00 Cr	Rs. 10.00 Cr
2. Undertake extensive rain water harvesting in the undulating slopes of the Red and Laterite zone	IWRD WRIDD SWID Forest Department	i. Identification of natural aquifers in the region ii. Identify the stretches of the hills where the trenches can be dug up to recharge the aquifers or rain water channels can be created to direct it to recharge zone iii. Digging up of staggered trenches with hedge row	Rs.300.00 Cr	Rs.300.00 Cr
3. Encourage surface water schemes to avoid ground water extraction	WRIDD	i. Create rain water harvesting structures in the form of ponds/dighis 20 ha CCA	Rs.90.00 Cr	Rs.60.00 Cr
4. Create small reservoir schemes such as check dams, that intercept rivulets, Nullahs, with canal system in this region	IWRD WRIDD Panchayati Raj	i. Identify the Nullahs and rivulets across which check dams can be constructed ii. Construct the check dams	5 km length Rs. 250.00 Cr	5 km length Rs.500.00 Cr
5. Complete the Subarnarekha Barrage	IWRD		5 km Rs. 400.00 Cr	5 km Rs. 800.00 Cr
6. Surface water treatment Plant		20 scemes to be completed, with 10 schems each in 12th plan and 13th paln respectively	Rs.100.00 Cr	Rs.100.00 Cr
7. Schemes for removing fluoride and other heavy metals		25 schemes to be completed in 12th and 13th plan respectively	Rs.37.50 Cr	Rs.37.50 Cr

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
D. Saline Coastal Zone				
1. Create more number of water harvesting schemes for accessing sweet water	SAD Department	Rain Water Harvesting Scheme with land Shaping	Rs.310.00 Cr	Rs.310.00 Cr
2. Desalination project of river water in coastal areas	PHED	50 schemes each to be completed in 12th and 13th plan	Rs.250.00 Cr	Rs.250.00 Cr
3. Surface water treatment plants	PHED	20 scemes to be completed within 12th and 13th pan	Rs.100.00 Cr	Rs.100.00 Cr
3. Reconstruct the Sundarbans embankment in vulnerable areas* *the major funding is from the central government and the World Bank	IWRD SAD Panchayet Deptt.	i. through public and private partnership to entrust the management of the embankment to public as well. ii. Undertake stabilisation of embankment slope, and iii. create drainage through the embankment to drain out high tide water.	Rs.50.00 Cr	Rs.50.00 Cr
4. Construct sluices to prevent the intrusion of saline water in channels where it does not exist	IWRD	i. Identify the channels ii. Fix the sluice gates	Rs.100.00 Cr	Rs.200.00 Cr
E. Scientific Assessments				

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
1. Establish high resolution weather monitoring, river inflow monitoring, hydrograph monitoring, and early warning system for floods	IWRD WRIDD SAD IMD INCOIS	i. Undertake study to understand the spatial resolution required to monitor rain fall and river inflow data ii. install automatic weather monitoring including rain gauge and water gauge stations at appropriate spatial resolution within all 23 Basins of West Bengal iii. Install hydrograph stations at high spatial resolution across the coast line ii. Install doppler radars (atleast 6 for 6 regions) for an overall coverage of the atmsopheric parameters iii. Create scientific capacities in the state to undertake real time analysis and hence near and long term forecasting of extreme rain fall and onset of monsoon and iv. Dissemination systems to make all farmers and the entire population aware of the impending events	Rs.100.00 Cr.	-
2. Assess water availability by region, assess current demand of water by sector and future demand by sector by by factoring in Climate change for short, medium and long term time lines	IWRD WRIDD PHE DIC	Undertake modeling activity, assess demand of water by sector using climate change projections and its impacts on water availability	Rs.2.00 Cr	-
3. Monitor quality of water to understand the impacts of warming of the atmosphere and for providing remedies	PHED, WRIDD	i. Underground water quality ii. surface water quality iii. Upgradation of water quality labs as per CPCB norms	Rs. 1.00 Cr Rs.2.00 Cr Rs. 5.00 Cr	Rs. 1.00 Cr Rs. 3.00 cr

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
4. Identify vulnerable areas of ground water contamination by point sources of industrial, municipal solid waste landfills and agricultural pollutants	WRIDD		Rs.1.00 Cr	Rs. 1.00 Cr
5. R&D on contamination Mitigation Devices (Model Study)	WRIDD		Rs. 2.00 Cr	-
7.Map water availability, Minor surface water bodies, Aquifers in time and space, and Water use in conjunction with land use and land classification	IWRD WRIDD		Rs.2.00 Cr	-
F. Policy related strategies				
1. Modernization of Irrigation system using Drip, Sprinklers systems	SWID, WRIDD, Agriculture Department	i. Undertake feasibility studies ii. Implement	Rs. 50.00 Cr	Rs. 50.00 Cr
2.Introduce pricing regulation for use of piped water for domestic use and drinking water	PHE	i. Feasibility studies ii Implementation	Rs.1.00 Cr	Rs.100.00 Cr
3. Undertake periodical census of medium and minor irrigation projects to check sustainability and also to detect dis-functionalities and	IWRD	i. One Survey in 12th plan ii. One survey in 13th Paln	Rs.10.00 Cr	Rs.10.00 Cr

	Institutions responsible	Actions	Cost in Crores (12th Plan)	Cost in Crores (13th Plan)
implement remedial measures				
4. Introduce variable water tax for irrigation purpose on both use of underground water and surface water sources in the short term and the in the long term metering of water usage may be done obtained from canals as well as from centralised underground sources	IWRD WRIDD	i. Study on pricing structure keeping in view the potential of payment of the different farmer categories	Rs.2.00 Cr	-
5. Extend compulsory rain water harvesting regulations for all houses in cities and town in WB	SWID Municipal Corporation of different towns and cities	i. Design to be developed for different housing types in different regions ii. Create incentive schemes for the same iii. Implement 25% of all towns in WB	i+ii Rs.6.00 Cr (@Rs.1.00 Cr. for 6 regions) iii.Rs.100.00 Cr	iii. Rs.100.00 Cr
GRAND TOTAL			Rs.4163.00 Cr	Rs.5323.00 Cr

Table 2: Strategies, Actions, Time lines and Budgets- Agriculture Crops

Strategy	Actions	12th plan	13th plan
1. Appropriate Crop Diversification in the various agro-climatic zones	i. Enhance ISOPOM ii. Undertake research on identifying the biodiversity of the 6 agro-climatic zones	i. ISOPOM: Rs.70.5 Cr ii. Research: Rs.2.5 Cr iii. Extend new crop diversification based on	i. ISOPOM: Rs 35.00 Cr ii. Research: Rs. 3.0 Cr

Strategy	Actions	12th plan	13th plan
	iii. Exploit the biodiversity of the region for crop diversification iv. Access to equipment for market ready products (dal tharshers and oil mills) v. Outreach to farmers through ATMA and PPP (capacity building of farmers, providing appropriate inputs to the farmers in terms of purchase and production of seeds, transfer of technology, chemicals, equipments, resource conservation technologies, farm implements, micronutrients)	biodiversity of the region to 50% of the districts in the 6 agro-climatic regions Rs.35.0 Cr iv. Access to equipments: One each for 50% of the 341 blocks in WB @ Rs1.10 Cr each total cost: 187.00 Cr v. Outreach for farmers through PPP Rs.6.0 Cr for 6 zones Total: Rs. 301.00 Cr	iii New Crop diversification to rest 50% of the districts in the 6 agroclimatic zones Rs. 35.0 Cr iv. Access to equipments to rest of the 50% of the blocks Rs. 200 Cr v. Outreach to farmers through PPP: Rs. 8.0 Cr for 6 zones Total: Rs. 281.00 Cr
2. Introduction of new cultivars of various crops including that of rice, and	i. Enhanced R&D for developing cultivars that are saline + flood tolerant for coastal zones	i. Rs. 5.00 Cr	i. Rs. 7.50 Cr

Strategy	Actions	12th plan	13th plan
wheat	ii Enhanced R&D for cultivars that can endure water stress iii Enhanced R&D for developing cultivars that can endure higher temperatures iv. Enhanced R&D for developing flood resistant varieties v. Introduction of cultivars that are saline tolerant and flood resistant on pilot basis in coastal zone on a pilot basis vi. Introduction of cultivars that can endure water stress in red and laterite zones on pilot basis vii. Introduction of flood resistant varieties in the old alluvial and new alluvial zones viii. Introduce cultivars that can endure higher temperatures in new and old alluvial zones ix. Introduce short duration wheat varieties in large scale in the old alluvial, hill zone and terai zone x. PPP component of out reach	ii. Rs. 2.5 Cr iii. Rs 2.5 Cr iv. Rs. 2.5 Cr v. Rs. 10.0 Cr. (in 50% of the area) vi. Rs. 10.0 Cr (in 50% of the area) vii. Rs. 20.0 Cr (in 50% of the area) viii. Rs. 20.00 Cr (in 50% of the area) ix. Rs. 30.0 Cr (in 50% of the area) x. 6.00 Cr Total: 98.5 Cr	ii. Rs. 3.0 Cr iii. Rs 3.0Cr iv. Rs. 3.0 Cr v. Rs. 11.0 Cr. (in 50% of the area) vi. Rs. 11.0 Cr (in 50% of the area) vii. Rs. 22.0 Cr (in 50% of the area) viii. Rs. 22.00 Cr (in 50% of the area) ix. Rs. 33.0 Cr (in 50% of the area) x. 8.00 Cr Total : 113.5 Cr
3. Encouraging indigenous cultivars	i. Research on identification of indigenous cultivars of each region	i. Rs. 10 Cr (around Rs. 3 Cr each for identification of cereals, pulses and oil seeds)	i. Rs 11.0 Cr

Strategy	Actions	12th plan	13th plan
	that are heat tolerant as well as can tolerate water stress using less nutrients but producing nutritive grains including cereals, pulses and oil seeds ii. Popularising hardy cereals, pulses and oil seeds in Red and Laterite zones as well as in old and new alluvial zones, where over extraction of ground water taking place due to excess water demand as compared to water availability	ii. in 50% of the blocks (Rs. 30 Cr @ Rs. 10 Cr for each region mentioned) Total: Rs.40.0 Cr	ii. Rs. 33.0 Cr (taking nto account price escalation by 10%) Total Rs. 44.0 Cr
4. Upscale Resource Conservation Technologies (RCTs)	i. Introduce "No tillage" in all agro-climatic zones, especially in Hill and terai zones where soil erosion is high ii. Introduce large scale water harvesting through ground water recharge using runoff from hillocks in red and Laterite zone iii. Introduction of drip irrigation in Red and Laterite zone iv. Promote water conservation for rice production through	i. No tillage: Rs. 4.00 Cr @ Rs. 50 lakhs for each zone and Rs. 1.00 Cr each for hill and Terai zones ii. @ Rs. 1.00 Cr for each of the 69 blocks in Red and laterite zone. Total cost: 69 Cr iii. Assess the economic dimension of Drip irrigation in red and laterite zone for cereals, pulses and oil seeds (Rs.75 Lakh @ Rs. 25 lakh for each type) iva. Upscaling SRI technology Rs. 18000 per ha (*source: http://www.hindu.com/seta/2005/04/28*	i. No tillage: Rs. 4.00 Cr (@ Rs. 50 lakhs for each zone and Rs. 1.00 Cr each for hill and Terai zones) ii. No cost iii. Introduction of drip iirigation @ Rs.18000 per ha in 1271.745 ha net sown area. Total

Strategy	Actions	12th plan	13th plan
	introduction aerobic rice, direct seeded rice, and SRI technologies appropriate for each zone v. Introduce farm mechanisation for planting technologies such as bed planting for rice and wheat and drum seeding for direct seeding in alluvial zones vi. Introduce brown manuring vii. Introduce sequential cropping of different crops, that can also	*/stories/2005042801071900.htm*) for 58.0 lakh ha on an average rice growing area in the state. So total cost for covering 10% area: Rs 1044.00 Cr ivb. Upscaling direct seeding for rice (Rs. 10,000 per ha for 20% of 58.0 lakh ha under rice. Cost Rs. 116.00 Cr ivc. Upscaling aerobic rice in 20% of the rice area @ Rs. 10,000lakh per ha. Total cost: Rs 116.00 Cr v. Bed planting+direct seeding for wheat @ Rs.10,000 for 50% of wheat area of 3.15 lakh ha in WB. Total Cost Rs.157.00 Cr vi. Brown manuring: Broad casting of 20/ kg of sesbania per ha of rice @ Rs.165/kg (current prices) in 10% of rice area. Cost: Rs.191.40Cr vii. generating awareness on sequential cropping Rs 6.00 Cr for 6 zones Total Cost: 1519.80 Cr	cost: Rs 2.29 Cr iva. Upscaling SRI technology Rs. 18000 per ha (*source: http://www.hindu.com/seta/2005/04/28 /stories/2005042801071900.htm*) for 58.0 lakh ha on an average rice growing area in the state. So total cost for covering 10% area: Rs 1044.00 Cr ivb. Upscaling direct seeding for rice Rs. 10,000 per ha for 20% of 58.0 lakh ha under rice. Cost Rs. 116.00 Cr ivc. Upscaling aerobic rice in 20%

Strategy	Actions	12th plan	13th plan
	augment nutrient into the soil for the next crop		of the rice area @ Rs. 10,000lakh per ha. Total cost: Rs 116.00 Cr v. Bed planting+direct seeding for wheat @ Rs.10,000 for 50% of wheat area of 3.15 lakh ha in WB. Total Cost Rs.157.00 Cr vi. broad casting of 22 kg of sesbania per ha of rice @ Rs.165/kg (current prices) in 10% of rice area. Cost: Rs.210.54 Cr vii. Generating awareness on sequential cropping Rs 8 Cr for 6 zones Total Cost: 1541.84

Strategy	Actions	12th plan	13th plan
			Cr
5. Effective soil nutrient management	i. Regular testing of soil and issuance of annual soil health cards to be made mandatory that identify the nutrient deficiencies of the soils for all agro-climatic zones ii. Government to provide support for amendment to the soil such as conventional fertiliser, other nutrients as per deficiencies of the soil including micro nutrients iii. Provide advisory on green manuring such as enrichment of the soil organically by growing a variety of crops on the land and then plough the green matter back into the soil	i. Soil testing @ Rs.60 per ha (*based on talks with expert)* for 50% of cropped area in 97.52 lakh ha of gross cropped area. Total Cost Rs. 29.56 Cr iia. Identification of soil amendments required by zone through research (Rs. 25 lakh for 1 zone). Total Cost Rs. 2.50 Cr iib. Soil Amendment to be provided in all districts @ Rs 2.00 Cr each 19 district . Total Cost Rs 38.00 Cr iii. Developing material for outreach and Outreach through PPP. Cost Rs. 10 Cr for all zones Total cost: 80.00 Cr	i. Soil testing @ Rs.70 per ha (*based on talks with expert)* for 50% of cropped area in 97.52 lakh ha of gross cropped area. Total Cost Rs. 34.13 Cr iia. Not required iib. Soil Amendment to continue to be provided in all districts @ Rs 2.20 Cr each 19 district . Total Cost Rs 41.00 Cr Total cost: 75.93 Cr
6. Promote organic ways for combating weeds, insect, pests and diseases and nutrient management	i. Undertake research for integrated pest management using organic additives	i. Rs. 25 lakhs each for exploring organic -pest repellants -pesticides -insecticides, -plant diseases (for diseases such as fungal, bacterial, blast, leaf blights, leaf spots, mildew	i. Continue research in these areas Rs. 2.00 Cr ii. Introduction on pilot basis each of

Strategy	Actions	12th plan	13th plan
		etc.) -use of micro-organism enriched mixtures -advantages of intercropping/mixed cropping -advantages for using parasites Total Cost: 1.75 Cr	these pest and disease control options developed during 12th plan in 6 zones Rs. 6.00 Cr (@ Rs.1.00 Cr for each pilot) Total Cost: Rs 8.00 Cr
7. Create seed banks	i. Currently seed banks in North and South Bengal are in operation. However, due to dry climate of the red and Laterite zone, it is one of the best areas to develop a seed bank for storage. ii. Explore the concept of developing village level seed banks	ia. Establishment of seed bank in Red and Laterite zone as per the Central scheme on "Development and strengthening of infrastructure facilities for production and distribution of quality seeds" Total cost of establishing a seed bank in red and laterite zone: Rs. 5.00 Cr (adhoc only, tentatively based on guidelines for the above mentioned scheme) iia. Training of farmers on varietal selection, storage of quality seeds through PPP, packaging, distribution & marketing. @ Rs.	ia. mantenance grant: Rs 50 lakh per year = Rs. 2.5 Cr

Strategy	Actions	12th plan	13th plan
		15000 per village, in 50% of the villages in West Bengal. Total number of villages 37190. Of this the government may bear 70% of the cost and the rest from private partnerships. Cost in 12th plan: Rs. 19.52 Cr iib. Establishment of self help groups to develop seed banks at village level (procurement of seed from farmers, sorting and seed treatment, storage in bins, packaging and selling) seeds each of different varieties. Initial funding @ Rs. 5,000 per village to 50% of the villages (*based on estimates averaged from ICRISAT and ADB funded project in few villages in India*) Total cost: 13.15 Cr Total Cost: Rs 37.50 Cr	iia. Training to 50% of the villages Rs. 21.00 Cr iib Funding for 50% of the villages @Rs.5,000 per village for village seed bank Cost: Rs 14.32 Total cost: 37.82 Cr
8. Enhance livelihoods of small and marginal farmers by introducing the concept of integrated Farming System by pooling in their fields for practicing each element of the Integrated Farming System	i. Identify the small and marginal farmers who will be willing to undertake the same in a cluster mode ii. Provide compensation to farmers till the IFS is remunerating iii. Support to be provided to farmers through public private partnership for a Jute-rice-wheat-	Cost of Jute production per bigha: Rs.1780 Cost of rice production: Rs.4300 Cost of mustard production Rs.1020 Cost of 3 cows: Rs.15000 Gobar gas plant: Rs 3700 Manure: Rs.4000 (@ 5 tons/animal) Cost of ducks: Rs.1000 Cost of digging pond (0.25 bigha) Rs. 2000 Total unit cost: Rs.32,800/-.	Upscale to 10% of small and marginal farmers in West Bengal. Total land holding of marginal farmers is 2758843 ha. Cost: Rs. 904.00 Cr

Strategy	Actions	12th plan	13th plan
	fish-livestock system	(*cost taken from actual cost of a farmer in West Bengal -ref: Farming System Approach to Improve IUE, Employment and Income in Eastern India, by B.C. BISWAS, published in Fertiliser Marketing News, Vol. 41 (5), pp. 6-12, amy 2010).* Total cost for 6 pilot projects: Rs.1.9 lakhs	
9. Real time crop monitoring and weather forecasting	Satellite (Terra) constantly broadcast data Anyone with the right equipment and software can download Free of charge Can store data for later download Develop contingency plan	Cost of establishment: Rs. 10 Cr	Maintenance and running: Rs 5 Cr
10. Setting up agriculture BPOs in each of the districts in West Bengal	This centre will be created through public private partnership. It will provide information to farmers through mobile telephony on ii. Climate of each day in terms of min/max temp, frost and dew conditions, sunshine availability, humidity, rainfall iii. 7 day climate forecast iv. Advisory on onset of monsoon v. Early warning about extreme events such as cyclones can be	Capital expenditure of equipment for 100 agents (Rs. 75.42 lakh)+ IT/internet expenses (Rs. 199.00 Lakh)+ training and operating expenses (1,06 Cr) + cost of running (by private party including rent of premises) Total Cost of setting up one BPO: Rs.2.20 Cr (cost of running not included. Therefore total Cost for setting up 19 BPOs in the state will be Rs. 41.8 Cr (Cost based on *Proposal for Setting up a BPO*	Running cost to be borne by private partner

Strategy	Actions	12th plan	13th plan
	provided direstly without calling up the BPO as messages to its clients vi. Advisory on cropping, water management, and nutrient management practices in the ensuing season vii. Information on availability of cultivars and seeds viii. Information on markets and prices ix. Information of vendors/ village banks on availability of seeds and grains x. Information on farm mechanisation tools availability etc xi. any other The scientific backstopping will be provided by the agriculture universities and research stations and research institutes. The climate information will be provided by the agrometeorological services of the IMD, NCMRWF, SAC Information on early warning on cyclones by ISRO	*unit In Tribal Taluka of Chhota Udepur of District Vadodara For Doubling of the Income of the people of the Area In 11th Five year plan Submitted to:Government of Gujarat, Social Justice & Empowerment Department (Tribal Development Department) Gandhinagar. December 2006. Submitted by: Shroffs Foundation Trust At & Post: Kalali, Tal. & Dist. Vadodara Ph. 0265 - 2680061, 2680702 Fax-0265 - 2680370)*	
11. Extend crop insurance to all small and marginal farmers	i. Identify holdings not covered yet (total no. of marginal land holdings i.e <10 ha) is 54.62 lakhs which	Premium being paid per ha now Rs. is Rs.563.87, of which 61.5% is paid by the state which is equal to Rs.346.99 per ha. SO in order	Rs. 500 Cr (tentative cost if the smae rates and same

Strategy	Actions	12th plan	13th plan
	corresponds to 2758843 ha. As per economic review 2009-10, area covered under insurance was 334.40 thousand ha in rabi 2008, and 210.53 acres in kharif ii. Reach out to cover these holdings through subsidies in the premium to be paid iii. Cover all seasons comprehensively instead of rabi and kharif insurances separately (summer, monsoon, autumn and winter)	to cover the total marginal holdings the government has to spend Rs. 95 Cr per year. So for 5 years the Total Cost may come to Rs.475 Cr. *(However this price is only based on current rates, and it may come down as the volume of coverage increases from present*)	subsidies continue)
Total		Rs. 2607.25 Cr	Rs. 3511.05 Cr

Table 3: Strategies, Actions, Time lines and Budgets - Fisheries

Strategy	Actions	12th plan	13th plan
1. Real time Monitoring of Fish shoals	Deep sea cum research vessel	i. Hiring of Monitoring –cum Research vessel including equipments @Rs.3 crores per year for 5 years (Rs. 8.00 Cr) ii. Construction & Maintenance of 40 units of Monitoring Cell @Rs. 20 lakh (Rs.15.00 Cr) iii. Manpower deployment –Remuneration and etc. for 5 years (Rs.1.35 Cr) iv. Contingent &unforeseen expenditure for	i. Zero cost of constructing monitoring cell, ii. Reduction in hiring charges of Vessel @ Rs.2 crore (Approx) per year for next 5 years

		5 years (Rs.0.65 Cr) Total: Rs 25.00 Cr	(Rs.10.00 Cr) iii. increase in remuneration @ 25% per year to manpower already deployed (Rs.4.12 Cr) iv. increase in Contingent & unforeseen expenditure for 5 years (Rs. 0.88 Cr) Total Cost: Rs. 15.00 Cr
2. Real time Weather Monitoring & Forecasting	Data procurement and analysis The cost of data procurement is only considered here as the other component will be done in house with existing manpower in the department	Sharing of data with IMD: @ Rs. 5.0 lakh per year per station for 22 stations. Cost: Rs. 1.10 Cr	i. Purchase & installation of Weather Equipments at 22 stations @Rs. 3.0 lakh (Rs.0.66 Cr) ii. Annual maintenance charges @ 10% of installation charges for 22 stations for 5 years (Rs. 0.28 Cr) iii. Manpower deployment on contractual basis @ Rs. 1000/- per day for 2 no. of person for 5 years for 22 stations

			(Rs. 3.96 Cr) iv. Contingent &unforeseen expenditure for 5 years @ 5% of installation charges for 22 stations for 5 years (Rs. 0.16 Cr) Total: Rs. 506.00 Cr
3. Mapping vulnerable fisher folk settlements	Through remote sensing and GIS at gram Panchayat level	i. Manpower deployment on contractual basis @Rs.200/- per day per person for 5 years for 18 districts (Rs. 0.65 Cr) ii. Purchase & installation of Computer with Internet facility for 18 districts @Rs.1.0 lakh per District (Rs.0.18 Cr) iii. Purchase of one GIS software @Rs. 20 lakh (Rs.0.20 CR) iv. Contingency for 5 years for 18 stations (0.17 Cr) Total Cost: Rs. 1.20 Cr	i. Manpower deployment on contractual basis @Rs.200/- per day per person for 5 years for 18 districts (Rs. 0.65 Cr) iii. Purchase of 4 GIS software @Rs. 20 lakh (Rs.0.80 CR) iv. Contingency for 5 years for 18 stations (0.17 Cr) Total Cost: Rs. 1.62 Cr
4. Forecasting and use of simulation Modeling	i. weather forecasting ii. soil testing iii. Training on fisheries and fishing practices to fisheries deptt. personnel iv. Data Generation	i. Manpower deployment on contractual basis @ Rs. 1000/- per day for 2 persons for 5 years for 18 districts (Rs.0.65 Cr) ii. Training on fishery and fishing practices (Rs. 0.70 Cr)	In 13 plan period the net cost may rise by 25 % and approximate cost in today's price for the next five years may

	vi. Bridging data gaps by for training fisheries deptt from grass root level to District Level, by Engagement of qualified survey personnel (at least Science graduate), facilitating exposure to modern equipments and computer systems and by undertaking Random field visit and routine supervision by higher officers	iii. Contingency (Rs. 0.85 Cr) iv. Data Generation- ocean and climate (Rs. 1.5 Cr) v. Bridging data gaps (0.90 Cr) Total Cost: Rs. 4.6 Cr	be Rs. 2.75 Crores+ Data generation (Rs 1.5 Cr)+ bridging data gap (Rs 1.35 Cr) Total Cost: Rs. 5.6 Cr
5. Mangrove Plantation	Specific programme for mangrove plantation along the canals, ponds and other water bodies in the Hoogli Matlah estuarine region for the conservation of the ecosystem bio-diversity, enriching its nutrient quality and quantity, provsing protection from storms and preventing soil erosion	Plantation of Mangrove, seed at the cost of Rs. 1/-, 80,000 plants per year for 5 years (Rs.0.04 Cr) Management cost & contingent expenditure @ Rs. 20,000/- per year for 5 Years (Rs 0.01 Cr) Total Cost : Rs. 0.05 Cr	Plantation of Mangrove, seed at the cost of Rs. 1/-, 80,000 plants per year for 5 years (Rs.0.04 Cr) Management cost & contingent expenditure @ Rs. 20,000/- per year for 5 Years (Rs 0.01 Cr) Total Cost : Rs. 0.05 Cr
6. Promotion of canal fisheries	i. Ecotourism coupled with canal fishery based on natural biophysical attributes & conservation of natural resources will be initiated in large Scale ii. Separately Canal fishery will be implemented atleast for 50 locations	i. @ cost Rs. 86 lakhs per location for 2 locations (Rs. 1.72 Cr) ii. Canal fishery for 25 locations @ Rs. 5 lakhs per unit (Rs. 1.25 Cr).	i. @ Rs. 1.00 Cr for 3 locations (Rs. 3.00 Cr) ii. Canal fishery for 25 locations @ Rs. 5 lakhs

		Total: Rs 2.97 Cr	per unit (Rs. 1.25 Cr). Total: Rs. 4.25 Cr
7. Development of sewage fed fisheries.	i. Excavation/dredging as well as management for the entire waste water resources for suitable aquaculture practices ii. Technlogy upgradation for managing sewage waste water fisheries	i. Excavation and dreding of 50% of the selected sites (Rs. 5.00 Cr) ii. Technology ugradation of 50% of the sites selected (Rs. 2.5 Cr) Total CostL Rs. 7.50 Cr	i. Excavation and dreding of 50% of the selected sites (Rs. 5.00 Cr) ii. Technology ugradation of 50% of the sites selected (Rs. 2.5 Cr) Total CostL Rs. 7.50 Cr
8.Protection and development of water bodies	Protection of seasonal and perennial water bodies (ponds and lakes). About 500 ha to be brought in under this scheme	i. Excavation of 75% of the area of water bodies envisaged to be excavated @ 1 Lakh per ha Total Cost : Rs 3.75 Cr	i. Excavation of 25% of the area of water bodies envisaged to be excavated @ 1.10 Lakh per ha Rs. 0.83 Cr
9.Providing life saving gears and equipments	i. Procuring 1070 life saving gears covering 10,000 fisheries ii. Procuring GPS Tracking systems for 17000 boats will be installed to approx 17,000 nos of boats with an unit cost of Rs. 30,000/- by the year 2020	i. 100% procurement @ Rs.400 per life saving gear ii. 50% of the boats installed with GPS Total cost: Rs. 0.43 Cr	Replacement of 50% gears which may become damaged procurement @ Rs.500 per equipment Total cost: Rs. 0.27 Cr
10. Promotion of solar	i. About 5000 nos of solar lights to be	i. 75% of 5000 coope-ratives and fishery	i. 25% of 5000

light	installed in co-operative societies and other fisheries projects and ii. another 10,000 nos of solar lights to be installed for model fishermen's villages with a	projects covered with a unit cost of Rs 0.5 lakh per unit (Rs 18.75 Cr) ii. 50% of 10,000 villages covered @ Rs 0.5 lakh per village (Rs. 25.0 Cr) Total cost: Rs 44.25 Cr	coope-ratives and fishery projects covered with a unit cost of Rs 0.5 lakh per unit (Rs 6.25 Cr) ii. 50% of 10,000 villages covered @ Rs 0.5 lakh per village (Rs. 25.0 Cr) Total cost: Rs 31.25 Cr
11. Block level laboratory cum training centre for fishery extension officers	The laboratory cum extension centres will: i. act as the single window service provider for all aquaculture and allied fields. ii. Undertake disaster monitoring and provide alerts Envisioned to set up 341 such centres of which 75 have been have already been established and 100 more units have been sanctioned in 11th plan through RKVY	Set up laboratory cum extension centres for 50% of the remaining 166 centres envisioned to be set up @ unit cost of Rs 3.6 Lkh per unit Total Cost: Rs. 2.98 Cr	. Set up laboratory cum extension centres for 50% of the remaining 166 centres envisioned to be set up @ unit cost of Rs 4.0 Lakh per unit Total cost: Rs 3.32 Cr
12. Research	i. Research on breeding endangered species ii. Research on fish virology and effects of pesticides and other pollutants	i. Rs 0.25 Cr ii. 0.20 Cr	i. Rs 0.25 Cr ii. 0.20 Cr

	iii. Survey of Migration route, biomorphological study and stock assessment of Hilsa & other species iv Research on Increasing Productivity & Brood Stock Management in Departmental Farms v. Research on developing species specific feed formulation for native threatened/endangered fish species through gut content analysis of the target species vi. Research on value added fish products vii. Studies to asses the impact of climate change on marine and coastal fish production in West Bengal & options for adaptive measures viii. Mass culture of different indigenous algal species on preparation of algal powder for ready to use fish feed & human supplementary feed	iii. 0.20 Cr iv. Rs 0.25 Cr v. Rs 0.15 Cr vi. Rs 0.25 Cr vii. Rs 0.25 Cr viii. 0.15 Cr Total: Rs 1.70 Cr	iii. 0.20 Cr iv. Rs 0.25 Cr v. Rs 0.15 Cr vi. Rs 0.25 Cr vii. Rs 0.25 Cr viii. 0.15 Cr Total : Rs 1.70 Cr

Table 4: Strategies, Actions, Timelines, and Budgets - Horticulture

Strategy	Actions	12th plan	13th plan
Protection from heat in all zones below hill and terai zones	In the short run, provide over head shade to fruit trees and construct greenhouses for vegetables, wherever the temperatures are exceeding the tolerance level of plants		
Undertake Research to help horticulture produce adapt to cliamte change	i. *D*evelop fruit and vegetable varieties that can adapt to excess salinity, can tolerate heat stress, and water stress. ii. Develop vegetable varieties that are fortified with nutrients that are absent in the soils they are grown. iii. Develop short rotation varieties of vegetables to adjust to the increasing winter temperatures		
Popularization of indigenous varieties:	i. Undertake mapping of existing traditional varieties fruits, vegetables, nuts, medicinal and aromatic plants grown in different regions having high resilience to the changing climate ii. Popularise these varieties through extension services using		

	the PPP mode Create seed banks of these varieties		
Crop diversification	Continue and intensify crop diversification programmes to include more crops which have wider adaptability.		
Improve floriculture programmes	Climate change will definitely impact production of flowers. Promotion of protected cultivation of high value commercial flowers should be focussed . Provide support for greenhouses.		
Production of off-season vegetables:	i. Exploit the productivity potential of higher altitudes where the the temperatures are likely to remain conducive to the growth of some vegetables, fruits, medicinal plants and flowers ii. Improve access to markets in these regions for improvement of rural economy		
Integrated Pest Management (IPM)	Steps to be taken to replace chemical control of diseases and pests by bio-pesticides, bio-control agents and other organic methods. Existing programmes need to be intensified to expedite the process		

	of organic conversion and New programmes in new areas to be launched.		
Water management system:	Undertake water management practices to use efficiently water and provide critical moisture for crop health. i. Ongoing programmes such as drip irrigation, construction of rain water harvesting structures, community ponds are to be strengthened to increase productivity with limited water and simultaneously conserving rapidly diminishing water resources. ii. Through efficient system of water management, it is targeted to utilise fallow land after paddy crop for cultivation of vegetables, potato and other horticultural crops during Rabi season		
Reducing weather related risks:	i. Establish weather stations at high resolution spatial scales for weather data collection at village level and ii. Sensitise the farming community		

	on weather related risks. iii. Advisory to farmers to make critical farming decisions for efficient crop management practices.		
Enhance infrastructure for ensuring livelihoods	Enhance infrastructure for storage and transport to markets of perishable horticulture products.		
Monitoring impacts of climate change:	Information system within the department needs to be strengthened with focus on collection of baseline data and a system to measure changes periodically with climate change impacts		

Table 5: Strategies, Actions, Time lines and Budgets - Livestock and livestock products

Strategy	Actions	12th plan	13th plan
1. Encourage breeding of small ruminants for livelihood security.	i. Assistance to small and marginal farmers to buy Bengal Goat , Garole Sheep, Ghungru Pig/ Improved breed and Broiler chicken ii. Assist in establishing a small farm within 1ha (very small farmers) iii. Undertake Male exchange programme of Black Bengal goat to arrest inbreeding depression iv. Undertake research to genetically upgrade Bengal goat, sheep, ghugroo, and pigs		

2. Strengthen disease investigation system	i. Develop disease forecasting systems ii. Establish disease surveillance system iii. Undertake research studies on a. the causes of diseases related to climate and b. the nature of emerging diseases due to emergence of new pests and vectors and c. developing control measures by involving livestock research institutions.		
3. Preventive health measures	i. Prepare long term strategies where by 100% population of the livestock get regularly vaccinated (large and small ruminants) ii. Set up Animal health camps to make people aware of adopting different control measures.		
4. Improved cattle sheds for alleviating heat stress in livestock:	i. Support farmers to augment their cattle sheds vis a vis Water sprinklers to enable them to have evaporative cooling and increase the air circulation in sheds so that cool air is retained, undertake evaporative cooling; ii. Create special community ponds to allow them to wallow in the ponds		
5. Feed and fodder development	To combat fodder shortage fodder development needs to i. have an additional impetus from the government by promoting mixed crop system, growing fodder on waste land, agro forestry etc.		

	ii. Supporting farmer centered fodder banks. iii. Undertake mineral mapping in different regions to assess mineral status and accordingly supply specific mineral mixture to farmers for growing fodder.		
6. Dairy development	***i.*** For enhancing the milk productivity even with increase in temperatures, extensive Artificial Insemination of the indigenous stock of the State has to be undertaken .		
7. Capacity building of farmers for effective adaptation to climate change	Strengthen Extension to provide advisory on Adaptation practices vis a vis i. right shelter for animals to protect them for heat stress, ii. right grazing practices that would enable the animals to be protected from heat, iii. the practices for identifying disease and mitigating them iii. creating feed mixes with proper nutrients for enhancing mild productivity, etc.		
8. Risk management:	Coverage of agriculture insurance may be extended to animal husbandry as well, especially for small and marginal farmers. i. Feasibility of the same needs to be studied before it can be launched. Other forms of risk management for farmers can be explored. ii. Extend coverage to at least 5% of the small and marginal farmers		

Table 6: Strategies and actions for the forestry sector

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
1. Spring recharge and enhancing ground water recharge at areas within the forests that are vulnerable to CC Aim: To water secure Sikkim • Integrating and climate proofing the works of the FEWMD, CAT, IWMP, and that undertaken in MGNREGA	1. Training of forest officials towards management of water sheds in the forests in the context of climate change 2. Identification and mapping of CC vulnerable spring sources, water sheds and mountain top lakes in drought prone areas of south and western sikkim. 3. Preparing spring specific project plan reports for implementation incorporating site specific techniques needed for water recharge, and water shed management 4. Implementation of projects	DF	Rs. 150.00 Cr	Rs.170.00 Cr
2. Enhancing quality of moderately dense forest, open forests and degraded forests Aim: (i) To improve the health of the forests; (ii) To improve ecosystem services and (iii) Enhance C sequestration potential of forests	i. Regulated grazing, invasive species eradication, management of insects and other pathogens ia Managing invasive alien species: - Launch study to collate information on problem species ib.Strengthen quarantine at state borders including that of soil, water, seeds, tubors, and bulbs etc ic. Strengthen mechansim of removal of invasive species through innovative outreach approaches id. Control through human use and as fertliser, food for livestock, fish, and poultry	FD	Rs. 600.00 Cr	Rs.600.00 Cr

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
	ii Adoption of short rotation species , iii actions towards reduction in forest fragmentation by conserving contiguous forest patches, iv eco restoration of degraded open forests, and v. Restoration of grass land vi. Restoration of Scrublands that are highly degraded forest/non-forest areas with scrub vegetation recording less than 10% forest density. vii. Promote native species -including sea buck thorn to improve soil moisture. . viii. Disease management practices to be put in place ix. Programme on Germ plasm conservation to be initiated to conserve native species x. Scope of planting trees in notified forest patches which are threatened by expanding urban/industrial development xi. Open spaces/green spaces like parks/wood lots set up on municipal land			

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
	xii Diffused planting such as on avenues and in households and Institutional lands, especially lands belonging to or allotted to business/industrial houses and educational institutions with trees that also support wealth of flora and fauna xiii Strengthening of Sustainable forest management cell (SFM) for continued monitoring of invasive species			
3. Linking Protected Areas Aim: To secure corridors for species migration to adapt to climate change	i. Connecting fragmented forests with 'corridors' to assist species migration. ii. Institute plans to mange and maintain the corridors by local stakeholders. iii. Plans for rapid agency responses towards crop-raiding, man-animal conflict, crop-insurance and hassle-free compensation for displacement if any. iv. Special studies to understand the feasibility of establishing such corridors and their effectiveness vis a vis natural dispersion and assisted migration in the context of climate change.	FD	Rs.600.00 Cr	Rs. 600.00 Cr
4. Mitigating impacts of land slides, storm surges and fast river run off	i. Installation of early warning systems and installation of hardware; real time monitoring (unmanned) with automatic data	FD SDMA	Rs. 200.00 Cr	Rs. 200.00 Cr

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
	transmission ii. State database on landslide prone areas and intensity of landslides to assess the risk of landslides iii. Implementation of Hazard Zonation Plan. iv. Reforestation of catchment areas and slope stabilization of landslide and Flash flood prone areas. v. Afforestation of degraded mangroves along the coast vi. Awareness generation on disaster preparedness Fires			
5. Enhanced mitigation of forest fires	i. Forest fire prevention and management i.i Early detection and management extended to higher altitudes, including community participation in management of fires i.ii Planting species in forests, immediately after the area is burnt with trees generated in the nurseries. Therefore nurseries have to be set up of Sal, Oak, and Conifer with adequate saplings available for future requirements i.iii undertake research to identify forest tree	FD	Rs. 100.00 Cr	Rs. 100.00 Cr

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
	species that would adapt itself at different altitudes.			
6. Preventing man animal Conflict to promote sustainable forests for the wild life to thrive within the limits of forests	i. Mobilizing Community initiatives ii. Identification of conflict areas iii. Capacity building, strengthening communication etc, sensitization of policy makers etc. iv. Population estimation of key species, v. Study on agriculture practices, vi. Phenological studies of wild edibles to enhance productivity of Wild indigenous Food /Fruit / Fodder /Fibre species inside Forest. vii. Promotion of Thorny Live-Hedge Fencing with indigenous species to minimize pollution, erosion; enrich soil fertility; attract pollinators; provide food, fodder, fuel, fibre;	FD	Rs.100.00 Cr	Rs.100.00 Cr

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
7. Understanding long term impacts of climate change on forests and monitor health of forests and its C sequestration potential	i Monitoring the health of the forests and its biodiversity - tree crown, tree growth, canopy structure etc. - ground vegetation, soil, forest floor - woody debris	DF Universities	Rs.200.00 Cr	Rs.200.00 Cr
8. Fast penetration of renewable energy technologies to prevent forests from getting degraded due to over extraction of fuel wood and biomass for fodder and fire as the climate warms	Rapid assessment and Identification of high fuel wood villages in 3 agro climatic regions, namely, hill region, red and lateritre region, and saline coastal region to identify opportunities of renewable energy technology interventions	FD Department of renewable energy	Rs300.00 Cr	Rs.300.00 Cr

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
9. Protecting and enhancing Livelihoods dependent on forests Aim: Enhance forest-based biomass production in the form of food, fuelwood, grass/fodder, timber, bamboo, cane and other NTFPs. The improved ecosystem services like water flows, biodiversity and carbon pools would further provide opportunity for augmenting incomes	i. Assessment of current livelihood opportunities ii. identification of new opportunities iii Mainstreaming climate concerns in the functioning of of FPC, SHGs etc.	FD	Rs.200.00 Cr	Rs. 200.00 Cr
	Promote community-based eco tourism enterprises especially with inclusion of margenalised section Promotion of diversification of eco-tourism related livelihoods - Souvenir making (handicraft) as a livelihood option		Rs. 100.00 Cr	Rs. 100.00 Cr
	Promote green Solid waste management strategies - Establish policy on extended producers responsibility for private firms, industries to encourage buy back policy of non-biodegradable waste			

Strategies	Actions	Agencies responsible	12th Plan	13th Plan
	Promote Agroforestry - Promote growing of Medicinal plants in the fringes of forests - Planting Agro-forestry species on fringes for Soil-binding and for increasing Soil Fertility - Promote other Cash Crops in Forest Fringe Area (Research)	FD	Rs. 100.00 Cr	Rs. 100.00 Cr
Grand Total			Rs.2650.00 Cr	Rs.2670.00 Cr

Table 7: Strategies, Actions, time lines and budgets for the health sector

	Current programmes/ projects addressing these concerns	Institutions involved	Actions in the 12th Plan	Approximate Cost at today's price	Remarks
A. Vector borne diseases including managing out breaks	National Vector Borne Disease Control Programme	Health Department	A1.Increased surveillance A2.Initiation of prompt complete treatment	Rs 6 Crores	Increase in incidence expected in 3 districts (Darjeeling, Malda, Murshidabad) @ Rs 2 crore per district

	Current programmes/ projects addressing these concerns	Institutions involved	Actions in the 12th Plan	Approximate Cost at today's price	Remarks
			A3.Supply of LLIN to at risk populations		
B. Water borne diseases including managing outbreaks	State Programme	Health Department and Kolkata Municipal Corporation	A1 Increased surveillance of water source contamination and water borne diseases A2.Initiation of prompt treatment	Rs 30 crores	@ Rs 5 crores per year for the districts and Rs 1 Crore per year for Kolkata
C. Extreme Events including Physical and psychological impacts	State Programme	through the Hospitals	A1 Increased Surveillance of extreme events A2 Setting up of Intensive therapy units in hospitals of affected areas	Rs 60 crores	@ Rs 3 crores per district and 6 crores for flood prone areas of Sundarbans
D. Food security and malnutrition	State Programme	In collaboratio n with Social	A1 Increased surveillance for evidence malnutrition	Rs 40 crores	@ Rs 2 crores per district and 4 crores for Kolkata

	Current programmes/ projects addressing these concerns	Institutions involved	Actions in the 12th Plan	Approximate Cost at today's price	Remarks
		Welfare Department and Kolkata Municipal Corporation	including micronutrient deficiencies A2 Setting up of nutrition clinics in affected districts A3 Scaling up of positive deviance programme		
E. Disaster preparedness (cyclones, sea level rise, extreme precipitation leading to flooding	State Programme	through the Public Health Branch and Hospitals	A1 Increased surveillance A2 Improving communication network A3 Retrofit vulnerable infrastructure	Rs 30 crores	@ Rs 5 crores per year for the districts and Rs 1 Crore per year for flood prone areas of Sundarbans
F CC and increase in air pollution	State Programme	through the Public Health Branch and	A1 Increased Surveillance of Respiratory Tract	Included with B Above	

	Current programmes/ projects addressing these concerns	Institutions involved	Actions in the 12th Plan	Approximate Cost at today's price	Remarks
		Hospitals and Kolkata Municipal Corporation	Illnesses A2 Setting up of Intensive therapy units in hospitals of affected area		
G research on CC and Health	State Programme	In collaboration with Universities and other research institutes	A1 Operational research on various issues	Rs 10 crores	
H .Capacity building	State Programme	State Health Training Institutes	A1Identification of training needs A2 Preparation of modules A3 Training of trainers A4 Cascading trainings up to field	Rs 60 crores	@ Rs 3 crores per district and 6 crores for Kolkata

	Current programmes/ projects addressing these concerns	Institutions involved	Actions in the 12th Plan	Approximate Cost at today's price	Remarks
			level staff		
I. Introducing mobile clinic for flood prone areas as the dispensaries also get flooded during that time and helicopter medical services for landslide affected people in hilly areas	State programme		i. set up 6-7 mobile boat units for flood prone areas ii. hiring of one helicopter for rescue and first aid iii. Enhance the orthopedic component of the three subdivision hospitals in the hill region	Rs. 12 Cr Rs. 5 Cr Rs. 5 Cr	Rs. 6 Cr for maintenance of units and staff Rs 2.5 Crore for setting up of the units Rs. 2.5 Cr for maintenance of unit
J. Inclusive policies	State Programme		A1 Identification of vulnerable groups and their specific problems A2 Capacity building	Rs 20 crores	@ Rs 1 crore per district and 2 crores for Kolkata

	Current programmes/ projects addressing these concerns	Institutions involved	Actions in the 12th Plan	Approximate Cost at today's price	Remarks
			of the community A3 Addressing the specific needs identified		

Note: The details of the health care centres that are proposed to be developed are:

1. Setting up/improvement of intensive care units:
Purulia, DH, Raghunathpur SDH, Suri DH, Bankura Sammelani Medical College Hospital, Bolpur SDH, Rampurhat SDH, Nadi DH, Medinipur DH, Kharagpur SDH, Raiganj DH
2. Retrofitting and enhancing facilities at institutions for adaptation to floods and other natural calamities:
Diamond Harbour SDH, Kakdwip SDH, Sandeshkhali RH, Haora RH, Gosaba RH, Minakhan RH, Sagar (Rudranagar), RH, Madhab Nagar RH, Malda DH
3. Setting up of orthopaedic units:
District Hospital Darjeeling, Kurseong SDH, Kalimpong SDH
4. Setting up and running microbiology and entomology surveillance labs"
Cooch Behar, Jalpaiguri, Darjeeling, Malda, Uttar Dinajpur, Dakshin Dinajpur, Nadia, Murshidabad, Birbhum, Purulia, Purba Midnapore, Howrah, Hooghly, N 24 Parganas, S 24 Parganas, Infectious disease Hospital Kolkata
5. Setting up of mobile boat units:
Canning, Daimond Harbour, Kakdwip, Baruipur, Contai, Basirhat

Table 8: Action plan for electricity sector - Adaptation

Strategies	Fund available	Institutions to be involved	Actions in 12th plan	Approx. cost in today's price	Actions in 13th plan	Approx. cost in today's price
A. Unlocking the market for Energy Efficiency						
Developing the ecosystem for Perform-Achieve-Trade	Depends on State contribution - GoI will match amount	WBERC, BEE, SDA for Energy Conservation, WBPCB	Energy audits and development of Specific Energy Consumption norm for designated Industries		Review of action and outcome. Improved goal setting.	
		CII, ASSOCHAM, FICII, Industry Associations, WB Federation of Commerce and Industry	Target setting for designated industries through national/international benchmarks and consultation			
		IFCI, REC, NABARD, IREDA, PFC	Development of Monitoring and Verification Protocol			
			Empanelment of Energy auditors and Electricity Services Companies (ESCO) for baseline measurements			
		Financial Institutions	Enunciate methodology for Perform-Achieve-Trade and test-run for limited period			

Strategies	Fund available	Institutions to be involved	Actions in 12th plan	Approx. cost in today's price	Actions in 13th plan	Approx. cost in today's price
			Award Energy-saving certificates			
			Create platform for trading in ESCerts, accounting and depository protocols			
Leveraging International Financial Instruments for promotion of energy efficiency			Engage with bilateral and multi-lateral fund (like the DFID Innovation Fund) managers to engage and prepare project reports for funding			
Leverage CDM for designated sectors			Prioritize designated end-use sectors - Household energy, Municipal DSM, designated industry clusters			
			Plan of Action after baseline studies, energy demand growth studies and sample energy savings potential studies			

Strategies	Fund available	Institutions to be involved	Actions in 12th plan	Approx. cost in today's price	Actions in 13th plan	Approx. cost in today's price
			Enable Public sector leadership with adequate financing and aggregate projects for critical mass.			
			Identify CDM potential in various sectors, pilot initiatives with adequate MVP to build state CDM roadmap with target			
Create Energy Efficiency Markets			Create demand for energy services through state-funded energy retrofit projects in the public sector			
			Develop guidelines for ESCOs and accredit them through ICRA/CRISIL or similar organizations			
			Support institutions in implementing curriculum and preparing students for national accreditation exams			

Strategies	Fund available	Institutions to be involved	Actions in 12th plan	Approx. cost in today's price	Actions in 13th plan	Approx. cost in today's price
Incentives to State government undertakings to take up energy efficiency			Policy guidance to state PSU to take up energy efficiency in their facilities - energy audits, energy efficient procurement, adoption of ECBC, etc.			
			Energy efficiency performance index (EEPI)to be developed by expert committee (DoP&NES, BEE-SDA, PWD) and added to MoU from 2013-'14			
			Develop guidelines for Energy Efficient public procurement with rationalization enabling retrofit in existing buildings and ECBC norms for new buildings			

Table 9: Strategies for Electricity sector- Mitigation

Strategies	Current programmes/projects	Fund available	Implemented through (institution/programme/project)	Actions in next 5 years	Approx. cost in today's price	Actions Plan in next 10 years	Appr. cost in today's price
A. Risk Assessment of Climate Impacts on Energy Services							
Assessment Studies and Simulations				Risk Assessment of energy sources - hydro, coal, gas, solar, wind, biomass, etc. - in anticipated climate change situations (variable rainfall, temperature, extreme events)			
				Risk Assessment of energy infrastructure in climate change situations including extreme events			
				Risk assessment of energy demand			
B. Mainstreaming Risk-adaptation strategies in Energy Planning and Provision							

Strategies	Current programmes/projects	Fund available	Implemented through (institution/programme/project)	Actions in next 5 years	Approx. cost in today's price	Actions Plan in next 10 years	Appr. cost in today's price
Identification of risk-reduction strategies				Identification and Prioritization of adaptation strategies - desilting in dams, relocation of selected infrastructure, strengthening			
Mainstreaming strategies into energy infrastructure planning, implementation and maintenance				Include risk-reduction elements as components of energy planning, implement and review in real-time events; retrofit existing infrastructure			
Review and Revise				Benchmark and Review			

Table 10: Action Plan for Habitat - Adaptation

Strategies	Current program/projects	Fund available	Implemented through (institution/ program /project)	Actions in 12th plan	Approx. cost in today's price	Actions Plan for 13th plan	Approx. cost in today's price
A. Increase Water Security							
Conservation of water Resources	TFC, UIG, UIDSSMT		DMA,UDD, PHED & all ULBs	Rain Water Harvesting to be made mandatory in all public buildings of A,B, C class Towns		Extend to other buildings exceeding set criteria and expand to other ULBs	
				To replace all ground water extraction processes by surface water treatment system wherever feasible - 30 ULBs		36 ULBs can be covered under this program	
Energy Efficient Water Supply System	TFC, UIG, UIDSSMT		DMA,UDD, PHED & all ULBs	Continuity of supply of Water To replace all existing intermittent water supply and direct pumping system with 24X7 water supply program with gravity distribution system to reduce pumping hours with less energy consumption in 59 nos. Towns.	150 Crore	To replace all existing intermittent water supply and direct pumping system with 24X7 water supply program with gravity distribution system to reduce pumping hours with less energy consumption in remaining Towns.	260 Crore
Reduction in water supply	TFC, UIG, UIDSSMT		DMA,UDD, PHED & all	Metering of the entire system	1000 Crore	Metering of the entire system	500 Crore

Strategies	Current program/projects	Fund available	Implemented through (institution/ program /project)	Actions in 12th plan	Approx. cost in today's price	Actions Plan for 13th plan	Approx. cost in today's price
losses			ULBs	To install meter at generation point, intermediate points and at consumer ends for all towns under category A to C		To install meter at generation point, intermediate points and at consumer ends for all towns under category D to E	
Recycling and reuse of waste effluent	TFC, UIG, UIDSSMT			Pilot demonstrate and enforce Waste water recycling for water sustainability	100 Crore		
B. Enhanced Monitoring, Awareness Building and Ensuring Preparedness							
Enhanced Monioring Systems for Early Warning			DMA,UDD, All PRIs/ULBs	Enhanced monitoring systems for Temerature, rainfall, stream-flows	50 Crore		
			DMA,UDD, All PRIs/ULBs	Awareness Building for Citizen Action in case of extreme events	50 Crore		
			DMA,UDD, All PRIs/ULBs	Shelter, Food and Health facilities for Poor households in times of extreme events			
C. Enhanced Design Elements to Strengthen Lifeline Infrastructure							
Review Design elements for coping during extrement events			DMA,UDD, All PRIs/ULBs	Enhanced monitoring systems for Temperature, rainfall, stream-flows	50 Crore		

Strategies	Current program/projects	Fund available	Implemented through (institution/ program /project)	Actions in 12th plan	Approx. cost in today's price	Actions Plan for 13th plan	Approx. cost in today's price
Pilot improved designs			TCPO, Engineering Wings, PR&RD, DMA	Pilot, Demonstrate, Review	10 Crore		
Assess and Incorporate in normal planning routine				Incorporate in Bye-laws, Building Code, Guidelines for all lifeline infrsatructure elements			

Table 11: Action plan for Habitats- Risk Mitigation

Strategies	Current program/projects	Fund available	Implemented through (institution/program /project)	Actions in years 0-5	Approx. cost in today's price	Actions Plan in years 6-10	Approx. cost in today's price
A. Strengthen and Enhance Ongoing M&E Systems along with Enforcement Capacities							
Create systems for ongoing pollution monitoring, analysis	Abatement of Pollution	5 Crore	WBPCB	Strengthen existing capacities and infrastructure in WBPCB; To extend ambient Air quality monitoring and include systems for GHG emission monitoring	25.0 Crore	To discuss withy different missions and set up appropriately designed M&E infrastructure and carry on-going data collection to be made available to Knowledge Mission	10 Crore

Strategies	Current program/projects	Fund available	Implemented through (institution/program /project)	Actions in years 0-5	Approx. cost in today's price	Actions Plan in years 6-10	Approx. cost in today's price
				Devise methodology for a rapid assessment of GHG emissions at ULB level; Implement and assess strategic emission reduction options for different ULB types emerging.	0.25 Crore		
Strengthen existing systems for achieving enforcement	Abatement of Pollution	0.5 Crore	WBPCB, Institutes, DMA, UDD, Industries	Strengthen existing Monitoring authority with a view of enforcing rules and punishing non-compliance	5 Crore	Verify compliance	
				Information collected will update knowledge base and also be used in Awareness Program.		Update Knowledge-base	
				Design and Implement mass awareness	5 Crore	Continue awareness building in discussion with various state	10 Crore

Strategies	Current program/projects	Fund available	Implemented through (institution/program /project)	Actions in years 0-5	Approx. cost in today's price	Actions Plan in years 6-10	Approx. cost in today's price
				camapign for Climate change issues and current data results; Involve Schools, Colleges, NGOs and Pvt. Sector		missions	
B. Risk Assessment of Climate Impacts on Lifeline Infrastructure							
Assessment Studies and Simulations	NDMA	NIL	State Disaster Management Authority, DPR&RD, DMA&UD	Risk Assessment of lifeline infrastructure - roads, water supply, sewerage, power transmission, etc. - in anticipated climate change situations (variable rainfall, temperature, extreme events)	1 Crore		
				Risk Assessment of lifeline infrastructure in climate change situations including extreme events			

Strategies	Current program/projects	Fund available	Implemented through (institution/program /project)	Actions in years 0-5	Approx. cost in today's price	Actions Plan in years 6-10	Approx. cost in today's price
B. Mainstreaming Risk-adapatation strategies in Service Infrastructure Planning and Provision							
Identification of risk-reduction strategies	JNNURM			Identification and Prioritization of adaptation strategies - desilting in dams, relocation of selected infrastructure, etc.	3 Crore		
Mainstreaming strategies into infrastructure planning, implementation and maintenance				Include risk-reduction elements as components of infrastructure planning, implement and review in real-time events; retrofit existing infrastructure			
Review and Revise				Benchmark and Review			

Table 12: Adaptation Strategies, Actions and Timelines- Water Resources- Darjeeling Himalayas

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
i.Develop a water policy for the district to guide distribution and management of water resources keeping in view the typical circumstances of the hilly and the terai regions	Develop policy through stakeholder consultations		a. Undertake series of meetings b. Develop policy Rs . 0.10Cr	-
ii. Create additional storage capacities to store excess runoff water in the monsoon and water from additional rainfall to be received during Oct-Dec with respect to base line in the hill region	Build Additional water harvesting structures such as reservoirs, roof top water harvesting structures on commercial, and government buildings to catch the run off as well as rain fall directly for augmenting the water storage capacity of the hill region. Also renovate/repair old reservoirs	IPHED	a. Estimate water demand keeping in view the increasing temperatures as well as increase in population both for the towns as well as rural areas in the future (next 100 yrs). - Rs. 0.20 Cr b. Renovate old reservoirs to avoid leakages – Rs.100.00 Cr c.Identify the areas where the reservoirs and water harvesting structures can be built to meet	Build 50% of the structures Rs 200.00Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			demand – Rs 0.50 Cr d.Build 50% of the structures including water distribution systems – Rs.200.00Cr	
iii. Prepare for combating adverse impacts of projected rise in extreme precipitation events – soil erosion, land slides, flash floods	Update maps of land slide prone area map	GSI DMA	Identify the potential land slide prone areas and update the existing map for Darjeeling hill areas Rs.5.00 Cr	
	Develop action plans to fortify the landslide prone areas - soil conservation measures and anti slide protection measures in land slide prone area etc. and implement measures	PHE Deptt of Agri Department of Agriculture Municipal Authority Siliguri Municipal Authority Darjeeling	a. Develop the action plan within 1st two years of 12th plan- Rs. 0.50 Cr b. Implement soil conservation and anti slide measures in 50% of areas Rs. 200.00 Cr	a.Implement soil conservation and anti slide measures in 50% of areas Rs 200.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
	Create canals for diverting excess water in rivers during flash floods	Deptt of Irrigation and Flood Control Municipal Authority Siliguri	a. Identify the nodes through which excess waters can be diverted b. Implement construction Rs 500.00 Cr	Finish construction of water diversion canals Rs.500.00 Cr
	Improve drainage system of the Siliguri area to prevent water logging after flash floods especially in the tea estate areas in and around Siliguri	Siliguri Municipal Authority	Identify the works required to improve the drainage system- such as dredging of drains, building extra drains, building channels etc. Implement 25% of the works Rs 50.00 CR	Implent 75% of the works Rs 150.00 Cr
i.Promote efficient use of water and deter wastage	The coverage being now provided to households through JNNURM across Siliguri needs also to be connected with water meters to promote water efficiency and discourage	PHE	Cover 50% of the households Rs 100.00 Cr	Cover rest Rs.100.00 cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
	wastage Darjeeling water supply is house to house but it also needs to connect the connections with meters to promote water use efficiency and deter wastage.		Rs 75.00 Cr	Rs 75.00 Cr
v. Prepare monitoring and evaluation plans to check the integration of climate change concerns in water management	-	Climate Change Cell, Government of West Bengal	Preapre the plan within the 1st two years of 12th plan including plan for feed back. Start analyzing the existing programmes to understand the areas were CC concerns can be integrated Undertake continuous monitoring	Continue Monitoring and evaluation activities Rs 2.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			and mid term evaluation of the strategies and actions implemented as a part of the SAPCC Advise the departments about the result of the evaluation so the implementing agencies in this case line departments can undertake mid term corrections Total: Rs 5.00 Cr	
Grand TotalL			Rs. 1237.00 Cr	Rs.1177.00 Cr

Table 13: Adaptation Strategies, Actions and Timelines- Agriculture Sector – Darjeeling Himalayas

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
i. Promote of indigenous food crops of the hills that can with stand heat stress	a.Identify the indigenous crops that are grown in the region such as pulses, oil seeds, rice, wheat, maize, and millet	Depart. Of Agriculture NABARD NGOs	Undertake research studies to Identify the crops in 1st two years of 12th plan Rs.1.00 Cr	-
	b.Create community seed banks for these varieties in villages	Deptt of Agri NABARD NGOs	Start the process of creating community seed banks 50% of the villages in Darjeeling district Rs.5.00 Cr	Continue the process of creating community seed banks in rest of the 50% of the villages Rs.5.00 Cr
	c.Conserve germplasm of these indigenous varieties	BCKV and University of North Bengal	Undertake activities towards conservation of germpalsm of indigenous varieties Rs 5.00 Cr	Continue action of conservation of germpalsm Rs.5.00 Cr
	Identify the impact of climate change on these crops and seeds	Agriculture Department, Noth Bengal	Undertake study on CC impacts on indigenous crops and seeds In 1st two yrs of 12th plan and publish the results	-

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			Rs0.50 Cr	
	Undertake studies to fortify them against the adverse impacts of climate change	BCKV	Undertake scientific study to fortify/ develop new strains of the indigenous varieties Rs 5.00 Cr	Continue study Rs 5.00 Cr
	Facilitate market creation for the indigenous produce		Advertising campaigns on nutritive values of indigenous crops Rs 0,50 Cr Undertake economic analysis to fix selling prices that are attractive for farmers to encourage them to grow Rs 0,.25 Cr	-Continue with additional varities aidentified Rs 1.00 Cr
ii. Facilitate agriculture cropping centres to survive at lower latitudes even at higher	Identify degraded lands that are cultivable at higher altitudes where cropping can take place along with forests- promote agroforestry at higher altitudes	Deptt of Agri Deptt of Forests	Demarcate land for agriculture at higher altitudes without encroaching upon healthy forest areas Rs .1.00 Cr	-

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
temperatures	Identify the requirement of shades in the lower latitudes and subsidise the same for framers	-do-	Undertake study and sell shades at subsidised rates Rs. 2.00 Cr	
iii.Undertake soil conservation and anti slide measures along hilly slopes to avert soil erosion and loss in soil nutrient	Narrow bench terracing can be implemented across hilly areas to avoid soil erosion	Deptt of Agri	Identify area where it need sto be done Implement in 25% of the areas Rs 25.00 Cr	Implement in 75% of the areas- Rs 75.00 Cr
	Promote aided natural regeneration during fallow period in the hills	-do-	Identify the areas where aided natural regeration can be practiced Implement in 25% of the area Rs 25.00 Cr	Implement in 75% of the area Rs 75.00 Cr
	Undertake contour bunding measures	-do-	Identify the areas where aided contour bunding can be practiced Implement in 25% of the area Rs 25.00 Cr	Implement in 75% of the area Rs 75.00 Cr
	Promote Zero tillage of soil both	-do-	Implement in 50% of the area	Implement in 50% of the

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
	in hills and terai		Rs 0.50 Cr	area Rs 0.50 Cr
	Promote green manuring in Terai		Identify areas and relevant green manuring species that can be sown Implement in 50% of the area Rs 10.00 Cr	Implement in 50% of the area Rs 10.00 Cr
iv.Promote Integrated Management of emerging and current pests and diseases	Develop Integrated Pest and Disease Management Plan that identifies crops suitable for a particular altitude, promotes use of certified diseases free seeds, identifies the organic fertilisers applicable, identifies the relevant bio pesticides, and other methods for avoidance of pest and diseases such as intercropping etc.	Deptt of Agriculture North Bengal University ICAR	Undertake study to Identify the crops that are prone to disease and pest and identify the potential pests and diseases that might emerge with increase in temperature Rs.5.00 Cr Develop IPMs for the existing diseases and pests and Disseminate to farmers	Continue to Develop IPMs for key crops Disseminate to farmers Rs 5.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			Rs 5.00 Cr	
	Facilitate availability of organic fertiliser and bio pesticides through training for developing them	KVKs	KVKs can facilitate the training Rs 5.00 Cr	KVks can continue to facilitate Rs 5.00 Cr
v.Intensify agrciluture activities to the Rabi season secure food	Identify the Rabi crops that can be grown Popularise the Rabi crops amongst farmers	Deptt. of Agri ICAR KVK	Identify the crops through research Rs 5.00 Cr Popularise rabi crops through KVK Rs 5.00 Cr	Popularise through KVKs Rs 5.00 Cr
Total			Rs.124.75	Rs.286.00 Cr

Table 14: Adaptation Strategies, Actions and Timelines- Biodiversity and Forests- Darjeeling Himalayas

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
1.Plan activities to reduce open forest area, enhance quality of moderately dense forests and protect the dense forests from degrading.	Monitor invasive species	Deptt of Forests	Undertake study to continuously monitor invasive species Rs 10.00 Cr	Continue study Rs 10.00 Cr
	Identify and plant non invasive species that can survive climate change and be beneficial to the ecosystem	Deptt of Forests	Identify open areas, moderately dense areas and dense areas Identify species suitable for these areas at different altitudes that can be beneficial to the ecosystem and can survive climate change Undertake systematic planting in 50% of the area Total: 500.00 Cr	Undertake planting in rest of the 50% of the area Total: Rs. 200.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
	Undertake Integrated Management of pests and diseases	Deptt of Forests	Develop protocol for Integrated Pest and Diseases management for each identifiable vegetation species in forests Implement the IPM on a case by case basis Rs.50.00 Cr	Continue to implement IPM Rs .20.00 Cr
	Adoption of short rotation species, preventing forest fragmentation, undertake eco restoration of degraded open forests, and restoration of grass land	Deptt of Forests	Identify short rotation crops Design plans for prevention of forest fragmentation by conserving contiguous forest patches. Develop plans for eco-restoration of degraded open forests	Continue with the activities Rs 500.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			Design plan for undertaking eco restoration of grass lands at the base of the Darjeeling Himalayas Rs 500.00 Cr	
	Develop a base line of the biodiversity of the floral and faunal species of the forests	Deptt of Forests	Undertake study in the 12th plan Rs 5.00 Cr	-
	Assess base line Carbon sequestration potential of the forests and project as to how much additional seuestration can occur if quality of forests is enhanved	Deptt of Forests	Undertake the study in the 12th plan Rs 1.00 Cr	-
	Assess the value of the forest products and ecosystem services and how it can improve through enhancement of quality of forests	Deptt of Forests	Undertake the study in the 12th plan Rs 1.00 Cr for all ecosystem	-

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			services Tentative Rs 5.00 Cr	
2. Empower communities living in and around forests to manage forests for enhancing its quality, for conserving biodiversity, preventing fire and benefitting through payment for ecosystem services rendered	Design a programme for community empowerment on forest resources with built in guidance for natural resource management, conservationof biodiversity , C sequestration and for marketing ecosystem services provided	Department of Forests	Design and impart training to communities on i.Ensure maintenance of quality of dense forests ii.Enhance quality of open forest iii.Iincrease forest cover iv. Conservation of biodiversity v. Enhance forest prduce vi. Enhance hydrological services vii. Undertake a study for valuation of ecosystem services and facilitate Marketing of the same	i.Monitor progress ii.Intervene where necessary iii.Upgrade technology of management iv.Train communities Rs 10.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			Rs 10.00 Cr	
3.Establish long term systematic monitoring of flora, and fauna in Darjeeling Himalays to understand the impact of all types of drivers including climate change	Establish methodology of monitoring and documentation of biodiversity on a regular basis through stakeholder consultation	Biodiversity Board Department of Forest Department of Envt.	To be carried out in 1st one year of 12th plan Rs 1.00 Cr	
	Establish a permanent long term rolling grant to engage the services of school, college, university students and NGOs, researchers from all across the state	Biodiversity Board Department of Forest Department of Envt. DST	Disseminate about the programme to students and NGos Offer scholarships for Ph.D Design school projects	Rs 50.00 Cr

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			Design projects at undergraduate level Seek projects from researchers for studying biodiversity Rs 50.00 Cr	
4.Devise suitable strategies for conservation and facilitation of species migration to adapt to climate change	Identify species that are most susceptible to climate change	Forest Depatt.	Launch a study to identify the most susceptible species likely to need migration as temperatures rise Rs 10.00 Cr	Continue study Rs 10.00 Cr
	Devise suitable strategies for their adaptation	Forest Deptt.	Develop plans for adaptation for facilitating species migration Rs 1.00 Cr	Continue work Rs 1.00 Cr
	Implement measures	Forest Depatt.	Implement the species migration measures	Continue to implement in other areas

Strategies	Actions	Department /Institutions Concerned	Action in 12th Plan	Action in 13th plan
			Rs 100.00 Cr (Rs 25 Cr for 5 years for 4 most suitable measures)	Rs 100.00 Cr
5.Devise strategies to prevent man animal conflict in a changing climate scenario	Develop land use planning by demarcating buffer zones between wildlife and human habitats	Forest Deptt	Identify forest areas where man animal conflict is imminent due to degradation of forests Demarcate areas for buffer zone Notify Buffer zone Rs 10.00 Cr	Continue with support Rs 50.00 Cr
	Design and develop buffer zone	Forest Deptt	Rs 100.00 Cr	
Total			Rs.1351.00 Cr	Rs 1441.00 Cr

Table 15: Strategies/Actions/Timelines and Budgets for Tea Sector – Darjeeling Himalayas

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan

1.Avoiding shifting of production centres to higher altitudes	Developing cultivars that can sustain higher temperatures and retain the typical Flavour	Tea Board Research and Development Unit Deptt of BioTechnology University of North Bengal	Undertake research in 12th plan Rs. 10.00 Cr	Continue research Rs 10.00 Cr
	Identifying agricultural practices that would enable retain original flavor for the new cultivar	-do-	Undertake study Rs 10.00 Cr	-Continue study Rs 10.00 Cr
2.Managing Tea from adverse impacts of Drought	Undertake research to develop cultivars that are drought resistant	-do-	Undertake study Rs 10.00 Cr	Continue study Rs 10.00 Cr
	Identify measures to retain soil moisture	-do-	Measures such as contour trenching amongst others and implement the same in 25% of the area Rs 10.00 Cr	Rs 90.00 Cr
	Explore possibilities of developing additional water storage capacities for storing	-do		

	runoff for its use for irrigation in water stress periods (Oct-March).			
3.Combating soil erosion and land slides in identified soil ersion and land slide prone areas.	Cover the soil and prevent it getting exposed to rain directly	Tea Board Tea Planters	Identify suitable measures such as no tillage, planting of grass, legumes, creepers etc. Undertake pilot study in limited area Implement suitable measures identified in measures in 50% of the area Rs 30.00 Cr	Implement in rest of the 50% of the area Rs 100.00 Cr
	Reduce speed of water along the slope through constructions	Tea Board Tea Planters	Identify contour lines and construct along them appropriately any of the following: -Wooden barriers -Bench terraces -Contour bunding and explore intercropping with pineapple Undertake construction in 25% of	Undertake construction in 75% of the areas Rs 100.00 Cr

			the area Total cost of study +implementation Rs 30.00 Cr	
4.Managing Pests and Diseases	Develop Integrated Pest and Disease Management Plans		Identify soil cover crop that is resistant to pests and disease Identify biofertiliser Undertake pilot study Implement measures in 25% of the area Cost: Study+Impl.=Rs. 30.00 Cr	Implement measure in 75% of the area Rs 100.00 Cr
Total			Rs 130.00 Cr	Rs.400.00 Cr

Table 16: Strategies/actions/timelines and budgets for medicinal plants, oranges and orchids – Darjeeling Himalayas

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
Medicinal Plants and orchids				
1.Facilitate retention of soil moisture in forest areas and in areas where medicinal plants are commercially grown	Liase with forest department to ensure afforestation of degraded forests, open forests with appropriate vegetation type and enhance quality of dense forests	Cinchona Directorate Forest Department Private growers if any Directorate of Horticulture, Darjeeling distt. Deptt of Horticultire WB	Develop guidelines for enhancing forest moisture appropriate for medicinal plants Identify areas and prioritise actions Implement rejuvenation/ ecorestoration of the forests Undertake activities to restore soil moisture of commercial plantations Rs 10.00 Cr	Continue the work Rs 10.00 Cr

		Horticulture mission		
2. Invest in research for developing thermal resistant cultivars of medicinal plants	Undertake research	Cinchona Directorate Forest Department Private growers if any Depatt of Biotechnology Horticulture mission Deptt of Horticulture	Identify 5 or 6 medicinal plants that have high commercial potential. Undertake research to develop thermal resistant cultivars for them Rs 12.00 Cr	Continue research Rs 12.00 Cr

Darjeeling Mandarin oranges				
Facilitate drainage of water during extreme rain fall events	Identify areas where water logging can be a concern Identify measures for drainage	Deptt of horticulture Horticulture mission	Undertake identification activities for water logged areas and drainage measures Implement anti water logging measures in 50% of the areas Rs 30.00 Cr	Continue implementation of measures in 505 of the areas Rs 75.00 Cr
Avoid soil erosion due to extreme rain fall	Identify areas where soil erosion is likely to go up Identify contours along which soil erosion measures will be implemented Identify measures to avert soil erosion Impelemnt soil erosion measures	Deptt of horticulture Horticulture mission	Identification activities to be carried out within 1st 2 yrs of 12th plan Implement measures in 25% of the areas in rest 3 years Rs 25.00 Cr	Continue implementing measures in rest of the 75% of the area Rs 75.00 Cr
Develop and implement IPDM	Develop packages of integrated pest and disease management using organic manuring and pest	Deptt of horticulture	Identify the diseases and pests afflicting oranges in Darjeeling	Continue with work to develop packages for new and emerging pests and

packages	and disease control agents for oranges	Horticulture mission	Identify the new pests that might infest the oranges with rising temperatures Develop a number of packages Pilot the packages for testing Disseminate selected package amongst farmers Rs. 10.00 Cr	diseases and disseminate Rs 10.00 Cr
Develop thermal resistant cultivars of Darjeeling mandarin oranges	Undertake research to develop thermal resistant cultivars of Darjeeling mandarin orange	Deptt of horticulture Horticulture mission	Rs 10.00 Cr	Rs 10.00 Cr

		Deptt of biotechnology ICAR		
Total			Rs 147.00 Cr	Rs 192.00 Cr

Table 17: Strategy for ecotourism – Darjeeling Himalayas

Strategies	**Actions**	**Deptt/ Institutions concerned**	**Actions in 12th Plan**	**Actions in 13th Plan**
Dvelop a ecotourism policy for the district	Actions are outlined in section 10.5.6	Deptt of Tourism Deptt of forests Panchyati Raj Gorkha Hill Council	Undertake stakeholder consultation meetings Identify issues that need to be taken care of in the policy Formulate and publish the policy Ensures measures of Monitoring to avoid mal conservation	

		Bidodiversity Board Deptt of Environment DST	practices adopted if any Provide small grantst to villagers to upgrade facilities in their homes to accommodate tourists Rs 1.00 Cr (Suggestive – only for meetings)	

Table 18: Adaptation strategies for managing Urban Habitats,Energy and Transport – Darjeeling Himalayas

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
1.A detailed assessment of water demand and availability in the future vis a vis rising temperatures due to	Undertake the study	PHE	Undertake the study in 1st 3 yrs of 12th plan Rs 0.50 lakhs	-

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
climate change				
2. Develop a blue print for addressing the additional energy requirement of the district in the context of climate change through the renewable energy route	Undertake study to assess demand in future and devise the renewable energy blue print to address demand	Renewable energy deptt	Undertake study in the 1st 3 yrs of 12th plan Map natural resource potential across the district – hydro, biomass including fuel wood, solar radiation Identify regions, target population and feasible renewable energy mix that can be used for generating electricity Implement pilots in different regions of the district with different renewable energy mix models	Extend supply to rest o fthe 50% of the population Rs 65.00 Cr

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
			Extend supply to 50% of the targeted population Rs 100.00 Cr	
3. Retrofit the designs of large Hydropower reservoirs keeping in view the climate change impacts:	Undertake study to assess the likely flow of glacier fed rivers with climate change in the Eastern Himalayn region Based on this study change, assess design changes required Introduce the design concepts in upcoming large hydro projects Retrofit the existing ones to meet the requirements of CC	National Hydrpower Corporation	study to assess the likely flow of glacier fed rivers with climate change in the Eastern Himalayn region- 1st three yrs of 12th plan Based on this study change, assess design changes required and develop protocol in the next two yrs Introduce the design concepts in upcoming large hydro projects Rs 10.00 Cr	Retrofit the existing reservoirs to meet the requirements of CC Rs 1000.00 Cr

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
4.Map and treat erosion prone areas in and around urban habitats	Undertake mapping acivities Undertake treatment of land in identified areas	Deptt of urban development	The climate change scenarios in conjunction with soil and techntonic characteristics across the state need to be mapped and final layer of land slide prone areas developed Identify appropriate measures for each area Apply measures in the last 2 yrs of 12th plan in 20% of the identified areas Rs 30.00 Cr	Apply anti land slide and soil erosion measures in rest of the 80% areas Rs 100.00 Cr
Develop Integrated transport plan for all the towns of Darjeeling district with initial focus of Darjeeling town and	Undertake study to assess future transport requirement and how it can be tackeled in the different cities in Darjeeling	Deptt of Tranpsort Ministry of	Undertake study in 12th plan Rs 5.00 Cr	Implement action in 13th Plan 2nd phase – Siliguri

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
Siliguri	Assess GHG emission projections and identify policy measures to reduce the same Implement policy measures and actions as listed in section 10.5.7 of this chapter	surface transport and Highways	Implement action from 2rd yr. One city in 1st phase – Darjeeling, Kurseong and kalimpong Rs 300.00 Cr	Rs 500.00 Cr
Total			Rs 445.50 Cr	Rs 1665.00 Cr

Table 19: Adaptation strategies/ Actions/ Timelines and budgets for managing Human Health in Darjeeling District

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
Bridging gaps in health infrastructure identified in NRHM review	Identify the year to year gaps published in the NRHM reviews and bridge the gaps	Deptt of Health GoWB	Assess the gaps and keep financial provision for bridging the gaps	Continue recruitment of fresh graduates

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
			May encourage a policy of compulsory village posting for a year fresh medical and nursing graduates to ensure health service delivery Rs 75.00 Cr	Rs 100.00 Cr
Communisation of Rural Health	Identify communities Identify functions of the communities Train communities on various health services they will be expected to deliver like managing finances, auditing finances, requisitioning of health workers including doctors, nurses, additional help, identification of people with symptoms of diseases and reporting ti the	Deptt of Health	Identification + Training Rs 100.00 Cr	Identification + Training Rs 100.00 Cr

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
	CHCs			
Scaling up IDSP intelligence resourcing	All the above can feed into the IDSP intelligence for policy development as well as reaching out with cure	Deptt of Health	The department will nedd to designate an officer in each CHC to report the intelligence gathered. Rs 1.00 Cr	-
Developing telemedicine facilities for remote areas	Identify specialists Develop tele communication facilities in all remote villages Train villagers to operate through skype Set up regular interactive sessions with the specialist	Deptt of Health Private sector under their CSR scheme can bear the cost of consultancy	Rs 100.00 Cr	Rs 100.00 Cr
Provision for air transport to district hospitals for critical patients from	Identify the number of such transportation required and buy.	Deptt of health	Rs 100.00 Cr	Rs 100.00 Cr

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
remote areas fitted with provisions of emergency action	Also identify areas where the helicopter can land in different villages	Private sector		
Undertake study to identify future disease prevalence and vulnerable population for policy augmentation in the health sector	Undertake the study, publish and disseminate results for informed policy making as well as upscaling infrastructure reeq. Including health service personnel deployment		Rs 0.50 Cr	-
Developing disaster risk reduction plan	Identify land slide prone areas Identify flood prone areas Develop systems for early weather warning including pollution levels Plan for rapid mobilisation etc	Deptt of health District Disaster Management cell State Disaster Management Authority	Develop the plan in 12th plan Publish the plan On ground keep ready the infrastructure requirements Undertake regular drills	Rs 10.00 Cr for upkeep

Strategies	Actions	Deptt/ Institutions concerned	Actions in 12th Plan	Actions in 13th Plan
			Incorporate the management plan in school curricumum Rs 100.00 Cr	
Total			Rs 476.50 Cr	Rs 500.00 Cr

Table 20 : Strategy, Action, Time line and budgets for Sundarbans

Strategy	Agencies to be involved	Action in 12th Plan	**Action in 13th plan**
Strategy to seek protection from increasing intensity of cyclones			
i. Undertaking a study to generate low , medium and high scenarios of impacts of climate change on cyclones, for 2030s, 2050s, and 2080s, to enable planning.	Climate Change Cell Department of Environment GoWB Deptt of Science and Technology IMD, Universities, Research Instts.	Undertake the study in the 1st 3 yrs of the 12th plan Cost: Rs 1.00 Cr	-
ii. Identify the level of tolerance of the various existing mangrove	Deptt of Biodiversity Deptt of Forests	Undertake the study within 12th plan	-

species to the different levels of projected salinity and flood water depth.	Deptt of Environment University and Research Instt.	Cost: Rs 2.0 Cr	
iii. Identify, the type and density of the mangroves required to act successfully as the 1st level of defense and accordingly, the mangrove plantation can be taken over.		Undertake the study in the 1st three years of 12th plan Cost: Rs. 1.00 Start mangrove plantation to bridge the gap in 25% of the identifies areas Rs 1.00 CR	Continue the activity in 13th plan in 75% of the areas Rs 3.00 Cr
iv. Scientifically design and construct/retrofit the type and height of embankment to protect the flood plains from the cyclonic waves and sea surges	Deptt. of Science and Technology, Identified Research Instt, I & W Deptt. Universities / IIT Research Instts. Private sector	Test designs of embankments in the laboratory through simulation, to test effectiveness of embankments to with stand different levels of wave heights and storm surges at various places in the Sundarbans, e.g. along the creeks, rivers and coast line Purchase of land, Start constructing the embankments based on	Continue the construction Cost: Rs 1000.00 Cr

		this input Cost: Rs 1000.00 Cr	
v. Design the existing houses on stilts based on the level of flood water height likely to be encountered in the future. Also Identify safe areas, and build cyclone / flood shelters	Department of Sundarban Affairs Panchyati Raj Ministry of Rural Development (MGNREGA) Housing Department District Administration	Identify the vulnerable region and the houses that need to be retrofitted Select the design of retrofitting Implement construction in 25% of the identified houses Construction of Cyclone / Flood Shelters Cost Rs. 200.00 Cr	Implement construction in 75% of the identified houses Rs 75.00 Cr
vi. Mobilise communities to take action rapidly and cyclone proof themselves when early warnings are sounded by authorities	NGOs Panchayati Raj National Disaster Management Authority and concerned deptt and cell in the state	Identify steps to make the communities aware about taking action when sounded about impending calamity Design the actions that they need to take for rapid mobilization – like getting in touch with relevant instt, accessing transport etc.	Continue dissemination Rs 5.00 Cr

		Disseminate through continuous workshops and messages in cell phones Undertake regular disaster management drills to make them disaster ready Rs 5.00 Cr	
vii. Strengthen communication- Roads/ Bridges/Jetties/ Ramps, etc and telephone communication	Deptt of Roads and Transport Deptt of Sundarban Affairs Deptt of Communication	Identify the roads that still need to be made fair weather roads and construction thereof; Identify / bridges / jetties / ramps, etc that still need to be made & their construction; Install telephone towers everywhere for easy communication Rs 200.00 Cr	Continue in 13th Plan Rs 200.00 Cr

viii. Building up infrastructure for sustainable livelihoods development : irrigation & drainage, electricity, storage, processing & market facilities,	I & W Deptt, Deptt of SA, Power Deptt, Deptt of Agricultural Marketing, Deptt of Horti & Food Processing, Deptt of Fisheries	Creation & rejuvenation of irrigation potentials through rain water harvesting and back water from Hooghly River; Drainage development for identified basins, Extension of electricity- conventional & non-conventional sources, Construction of multi-purpose cold storages, Setting up marketing centres, Rs. 200 crore	Continuation of works in 13th Plan Rs. 200 cr.
ix. Rehabilitation & renovation package for disaster hit households on the consequence of climate change	R.R. & R Deptt, Environment Deptt, District Administration	Settlement with necessary facilities, social services and alternative livelihoods, etc Rs. 100 cr.	Settlement with necessary facilities, social services and alternative livelihoods, etc Rs. 100 cr.
Total Cost		**Rs 1710.00**	**Rs 1583.00 Cr**
Protect agriculture productivity and livelihoods	○ Height and quality of the embank plays an important role in	Carry out 50% of the	Carry out 50% of the actions

	protecting agriculture in the region from additional salinity in soil due to projections of increasing intensity of cyclones ○ Increase irrigation facilities by increasing surface reservoirs such as ponds and *dighis* to store rain water ○ Introduce thermal resistant and salt tolerant rice cultivars ○ Promote commercial level coconut plantations in saline areas ○ Promote horticulture vegetable crops ○ Provide access to markets through construction of roads ○ Crop Insurance	actions Rs 100.00 Cr	Rs 100.00 Cr
Promote alternate livelihood opportunities	○ Develop a fishery policy may be formulated centering around conservation vis a vis climate change impacts. ○ Promote Inland and marine fisheries by building appropriate	Undertake policy formulation for promoting inland and marine fisheries Develop modeling capacities	Provide insurance cover to 50% of fishermen Rs 50.00 Cr

	infrastructure for cold storage and access to markets ○ Develop modeling capabilities for forecasting fish catch areas in marine and inland water environment ○ Provide insurance to fishermen against calamities. ○ Provide insurance to the stakeholders of allied sectors against calamities.	Provide insurance cover to 50% of fishermen Rs 100.00 Cr	
Enhance the accessibility to drinking water:	○ Extend pipe water connection to all households ○ Arrange to draw fresh water from western rivers flowing through sundarbans ○ Build over ground reservoirs to store rain water	Extend facilities to 50% of households Create infrastructure to use potable water from western rivers Create 50% of the planned reservoirs much above the ground to avoid salinisation due to sea level rise/cyclones/storm surges Rs 1000.00 Cr	Continue with rest of the 50% activities RS 100.00 Cr
Improve accessibility to health facilities:	○ Bridge gaps in the existing health infrastructure and health	Rs 200 Cr (Identification of gaps, process of communisation, and	Continue with the activities. Cost- Rs 100.00 Cr

	service delivery Communitise health service delivery ○ Develop telemedicine facilities ○ Develop rapid transport for critically injured – by pressing in helicopter services. Develop disaster preparedness to abate disease outbreaks and undertake regular drills.	development of disaster risk reduction plans have to start in 12th plan)	
Conserve biodiversity:	○ Continue with ongoing policies and actions of the Forest Department ○ Further research may be launched to understand the nature of impacts of climate change on Mangroves in terms of its floral and faunal biodiversity, to plan for afforestation measures and for conservation of fauna as per the dictates of the changing climate scenarios	Rs 5.00 Cr – research component	Rs. 100.00 Cr - Implementation of afforestation and conservation of flora and fauna activities

Annexure 2

Government of West Bengal
Department of Environment

No. EN/ 1108 /T-III-2/001/2010 Date : 12 /04/2010

NOTIFICATION

Whereas, climate change has emerged as single most challenge before us to sustain human development in future in a sustainable manner,

Whereas, planned adaptation and mitigation work can reduce the impact of anthropogenic climate change,

Whereas, Government of India has put in place a National Action Plan on climate change in the year 2008 which specifies the broad framework for course of action in climate related fields through eight national missions,

Whereas, Ministry of Environment, Government of India urged upon the states to frame their respective State Action Plan on climate change,

Whereas, the Government of West Bengal resolved to prepare their own State Action Plan,

Therefore, Governor is pleased to constitute the following two committees to prepare the State Action Plan on Climate Change.

A. Steering Committee
Chief Secretary, Government of West Bengal
Principal Secretary, Department of Environment, Government of West Bengal
Addl. Chief Secretary, Department of Forests, Government of West Bengal
Addl. Chief Secretary, Department of Power & NES, Government of West Bengal
Principal Secretary, Department of Science & Technology, Government of West Bengal
Principal Secretary, Department of Urban Development, Government of West Bengal
Principal Secretary, Department of Agriculture, Government of West Bengal
Principal Secretary, Department of Sundarban Affairs, Government of West Bengal
Principal Secretary, Department of Panchayat & Rural Development, Government of West Bengal
Secretary, Department of Municipal Affairs, Government of West Bengal

B. Drafting Committee
Shri Subrat Dhaundyal, IFS, CCF, Central, Forest Department
Shri Nabani Dey, WBCS (Exe.) Special Secretary, Urban Development Department
Dr. Pradip Sen, Jt. D.A. (Res), W.B., Agriculture Department
Dr. Kallol Kr. Mukherjee, WBCS (Exe.), Project Manager, CMU, KUSP

Shri Subhash Acharya, Jt. Project Director (Monitoring and Evaluation), Sundarban Development Board
Shri S.P. Gonchoudhury, Managing Director, West Bengal Green Energy Development Corporation
Shri Indranil Mukhopadhyay, Programme Officer, Panchayat & Rural Development Department
Dr. P. Chakrabarti, Chief Scientist, Science & Technology Department
Shri Debal Ray, Chief Environment Officer - Convenor

The drafting committee will be responsible for drafting the State Action Plan on Climate Change. They may constitute sector-wise working groups involving the line departments and experts. The working groups may hold consultations and come up with sectoral plans. It will be the responsibility of drafting committee to synthesize the sectoral plans into a State Action Plan.

The steering committee will review periodically the progress of State Action Plan preparation and provide guidance to the drafting committee.

The draft State Action Plan on Climate Change will be prepared within 6 months from the date of publication of this notification.

By the order of the Governor

Sd/-
(M. L. Meena)
Principal Secretary

No. EN/ 1108 /T-III-2/001/2010/1(9) Date : 12 /04/2010

Copy forwarded for information and necessary action to :-

1. Shri Subrat Dhaundyal, IFS, CCF, Central, Forest Department, Aranya Bhavan, 10A, LA Block, Sector – III, Salt Lake, Kolkata – 700 098
2. Shri Nabani Dey, WBCS (Exe.) Special Secretary, Urban Development Department, Nagarayan Bhavan, DF-8, Sector – I, Salt Lake City, Kolkata – 700 064
3. Dr. Pradip Sen, Jt. D.A. (Res), W.B., Agriculture Department, Writers' Buildings, Kolkata – 700 001
4. Dr. Kallol Kr. Mukherjee, WBCS (Exe.), Project Manager, CMU, Kolkata Urban Services for the Poor, Ilgus Bhavan, HC-Block, Sector – 3, Bidhannagar, Kolkata- 700 106.
5. Shri Subhash Acharya, Jt. Project Director (Monitoring and Evaluation), Sundarban Development Board, Mayukh Bhavan, Kolkata – 700 091
6. Shri S.P. Gonchoudhury, Managing Director, West Bengal Green Energy Development Corporation, Bikalpa Shakti Bhavan, J-1/10, EP & GP Block, Sector-V, Salt Lake Electronics Complex, Kolkata – 91
7. Shri Indranil Mukhopadhyay, Programme Officer, Panchayat & Rural Development Department, Jessoph Building, Kolkata – 700 001
8. Dr. P. Chakrabarti, Chief Scientist, Science & Technology Department, Bikash Bhavan, Salt Lake, Kolkata – 700 064
9. Shri Debal Ray, Chief Environment Officer, Environment Department

Sd/-
(S. Moitra)

Joint Secretary

No. EN/ 1108 /T-III-2/001/2010/2(10) Date : 12 /04/2010

Copy forwarded for information and necessary action to :-

1. P.S. Chief Secretary, Government of West Bengal
2. P.S. to Principal Secretary, Department of Environment, Government of West Bengal
3. P.S. to Addl. Chief Secretary, Department of Forests, Government of West Bengal
4. P.S. to Addl. Chief Secretary, Department of Power & NES, Government of West Bengal
5. P.S. to Principal Secretary, Department of Science & Technology, Government of West Bengal
6. P.S. to Principal Secretary, Department of Urban Development, Government of West Bengal
7. P.S. to Principal Secretary, Department of Agriculture, Government of West Bengal
8. P.S. to Principal Secretary, Department of Sundarban Affairs, Government of West Bengal
9. P.S. to Principal Secretary, Department of Panchayat & Rural Development, Government of West Bengal
10. P.S. Secretary, Department of Municipal Affairs, Government of West Bengal

Sd-

(S. Moitra)

Annexure 3

Government of West Bengal

Department of Environment

Writers' Buildings, Block – G, 2nd Floor

Kolkata – 700 001

N O T I F I C A T I O N

No. EN/3453/T-III-2/001/2010 Date : 16/12/2010

WHEREAS, Government of West Bengal has resolved to prepare State Action Plan on Climate Change and has constituted a Steering Committee and Drafting Committee vide notification no. EN/1108/T-III-2/001/2010 dated 12/04/2010,

WHEREAS, the Drafting Committee identified 10 sectors which are most climate sensitive in the context of West Bengal,

WHEREAS, Sundarbans as one such sector.

Therefore, in partial modification of Notification No.EN/ 3165 /T-III-2/ 001/2010 Date : 16 /11/2010 the Governor is pleased to constitute the following sectoral committee to prepare the sectoral report on Sundarbans for eventual incorporation into State Action plan on Climate Change

1. Prof. Amalesh Chowdhury – Member
2. Dr. Asish Kr. Ghosh – Member
3. Dr. Kalyan Rudra – Member
4. Dr. Sugata Hazra – Member
5. Dr. Manash Ghosh – Member
6. Representative of Bidhan Chandra Krishi Viswa Vidyalaya – Member
7. Representative of IIT Kharagpur
8. Representative of University of Animal & Fishery Science
9. Shri Subhash Chandra Acharyya – Convenor

The sectoral committee may co-opt any member as and when they feel the need for doing so.

The sectoral committee may discuss with the drafting committee any issues they consider relevant.

The sectoral committee shall take help of consultants engaged by either the State Government or any external agency on behalf of State Government in the matter of preparation of sectoral plan, vulnerability analysis and GHG emission inventory preparation.

The members of the sectoral committee, excluding the official members, shall be paid honorarium at a rate of Rs.500/- per sitting.

By order of the Governor,

Sd/-

(K.S. Rajendra Kumar)

Additional Chief Secretary to the Government of West Bengal

No. EN/3453/T-III-2/001/2010 /1(9) Date : 16/12/2010

Copy forwarded for information and necessary action to :-

1. Prof. Amalesh Chowdhury, Secretar y, SD Marine Research Institute, Sagar Island – 743 373
2. Dr. Asish Kr. Ghosh, President, Centre for Environment & Development, Kolkata.
3. Dr. Kalyan Rudra, Geographer and River Specialist, 453, Dum Dum Park, Flat-4A, Kolkata – 700 055
4. Dr. Sugata Hazra, Director, School of Oceanographic Studies, Jadavpur University, Kolkata – 700 032.
5. Dr. Manash Ghosh, Sundarban Development Board
6. Vice Chancellor, Bidhan Chandra Krishi Viswa Vidyalaya – He is requested to nominate a official member to function as a member in the sectoral committee of Sundarbans.
7. Director, Indian Institute of Technology, Kharagpur – 721 302. He is requested to nominate a official member to function as a member in the sectoral committee of Sundarbans.
8. Vice Chancellor, University of Animal & Fishery Science, 68, Khudiram Bose Sarani, Kolkata – 700 037. He is requested to nominate a official member to function as a member in the sectoral committee of Sundarbans.
9. Shri Subhash Chandra Acharyya, Jt. Project Director (Monitoring and Evaluation), Sundarban Development Board, Mayukh Bhavan, Kolkata – 700 091

Sd/-

(Debal Ray)

Chief Environment Officer

No. EN/3453/T-III-2/001/2010/2(2) Date :16 /12/2010

Copy forwarded for information to :-

1. The Secretary, Sundarbans Affairs Department
2. The Additional Chief Secretary, Environment Department.

(Debal Ray)

Chief Environment Officer

Annexure 4

Government of West Bengal
Department of Environment
Writers' Buildings, Block – G, 2nd Floor
Kolkata – 700 001
N O T I F I C A T I O N

No. EN/3528/T-III-2/001/2010 Date : 24/12/2010

WHEREAS, Government of West Bengal has resolved to prepare State Action Plan on Climate Change and has constituted a Steering Committee and Drafting Committee vide notification no. EN/1108/T-III-2/001/2010 dated 12/04/2010,

WHEREAS, the Drafting Committee identified 10 sectors which are most climate sensitive in the context of West Bengal,

WHEREAS, Energy Efficiency as one such sector.

Therefore, in partial modification of Notification No. No. EN/3166/T-III-2/ 001/ 2010 Date 16/11/2010 Governor is pleased to constitute the following sectoral committee to prepare the sectoral report on energy efficiency for eventual incorporation into State Action plan on Climate Change

1. Representative of State Electricity Distribution Company Limited – Member
2. Shri Angshuman Majumdar, Divisional Engineer, WBREDA - Member
3. Shri Jay Chakraborty, Divisional Engineer, WBREDA - Member
4. Dr. Tapas Kumar Gupta, Chief Engineer – Member
5. Shri S.P. Gon Chaudhuri, Managing Director, WBGEDCL – Member & Coordinator

The sectoral committee may co-opt any member as and when they feel the need for doing so.

The sectoral committee may discuss with the drafting committee any issues they consider relevant.

The sectoral committee shall take help of consultants engaged by either the State Government or any external agency on behalf of State Government in the matter of preparation of sectoral plan.

The members of the sectoral committee, excluding the official members, shall be paid honorarium at a rate of Rs.500/- per sitting.

By order of the Governor,

Sd/-

(K.S. Rajendra Kumar)

Additional Chief Secretary to the Government of West Bengal

No. EN/3528/T-III-2/001/2010/1(5) Date : 24/12/2010

Copy forwarded for information and necessary action to :-

1. The Chairman & Managing Director, State Electricity Distribution Company Limited, Bidyut Bhavan, Bidhannagar, Kol – 91 – He is requested to nominate a official member to function as a member in the sectoral committee of Sundarbans.
2. Shri Angshuman Majumdar, Divisional Engineer, West Bengal Renewable Energy Development Authority, Bikalpa Shakti Bhavan, Plot No. J- 1/10, EP & GP Block, Sector – V, Salt Lake Electronics Complex , Kolkata – 700 091.
3. Shri Jay Chakraborty, Divisional Engineer, West Bengal Renewable Energy Development Authority, Bikalpa Shakti Bhavan, Plot No. J- 1/10, EP & GP Block, Sector – V, Salt Lake Electronics Complex, Kolkata – 700 091.
4. Dr. Tapas Kumar Gupta, Chief Engineer, West Bengal Pollution Control Board.
5. Shri S.P. Gon Chaudhuri, Managing Director, West Bengal Green Energy Development Corporation Ltd., Bikalpa Shakti Bhavan, Plot No. J- 1/10, EP & GP Block, Sector – V, Salt Lake Electronics Complex, Kolkata – 700 091.

(Debal Ray)

Chief Environment Officer

No. EN/3528/T-III-2/001/2010/2(2) Date : 24/12/2010

Copy forwarded for information to :-

1. The Principal Secretary, Power & NES Department
2. The Additional Chief Secretary, Environment Department.

(Debal Ray)

Chief Environment Officer

Annexure 5

Proposed Members of the Science Advisory Council

Sl. No.	Members	Department/Organisation
	Departmental Officials	
1.	Secretary	Deptt. of Environment, GoWB
2.	Secretary	Deptt. of Sc. & Tech, GoWB
3.	Member Secretary	West Bengal Pollution Control Board
4.	Chief Environmental Officer	Deptt. of Environment, GoWB
5.	Director	Institute of Environmental Studies and Wetland Management
	Non-Official Members	
5.	Dr. Saroj Sanyal	Vice-Chancellor, BCKV
6.	Dr.H.K.Mazumdar	Director Grade Scientist of IICB, CSIR, GOI
7.	Dr.S.P.Sinha Ray	Former Member, Central Ground Water Board, GOI and Chairman, Fluoride Task Force Committee, GoWB
8.	Dr.A.K.Raha	PCCF, Deptt. of Forest, GoWB
9.	Dr.P.Chakrabarti	Chief Scientist, Deptt. of Sc. & Tech, GoWB
10.	Dr.S.Raha	Director, Bose Institute
11.	Prof. Sugata Hazra	School of Oceanography, Jadavpur University
12.	Prof. (Mrs.) S. Choudhury	Deptt. of Atmospheric Sciences, Calcutta University
13.	Prof. (Mrs.) S. Sen	Deptt. of International Relations, Jadavpur University
14.	Prof. Sujay Basu	Former Head, Deptt. of Electrical Engineering, Javavpur University and Director, Centre for Energy and Environmental Management
15.	Dr. Abhijit Mitra	Deptt. of Marine Sciences, Calcutta University