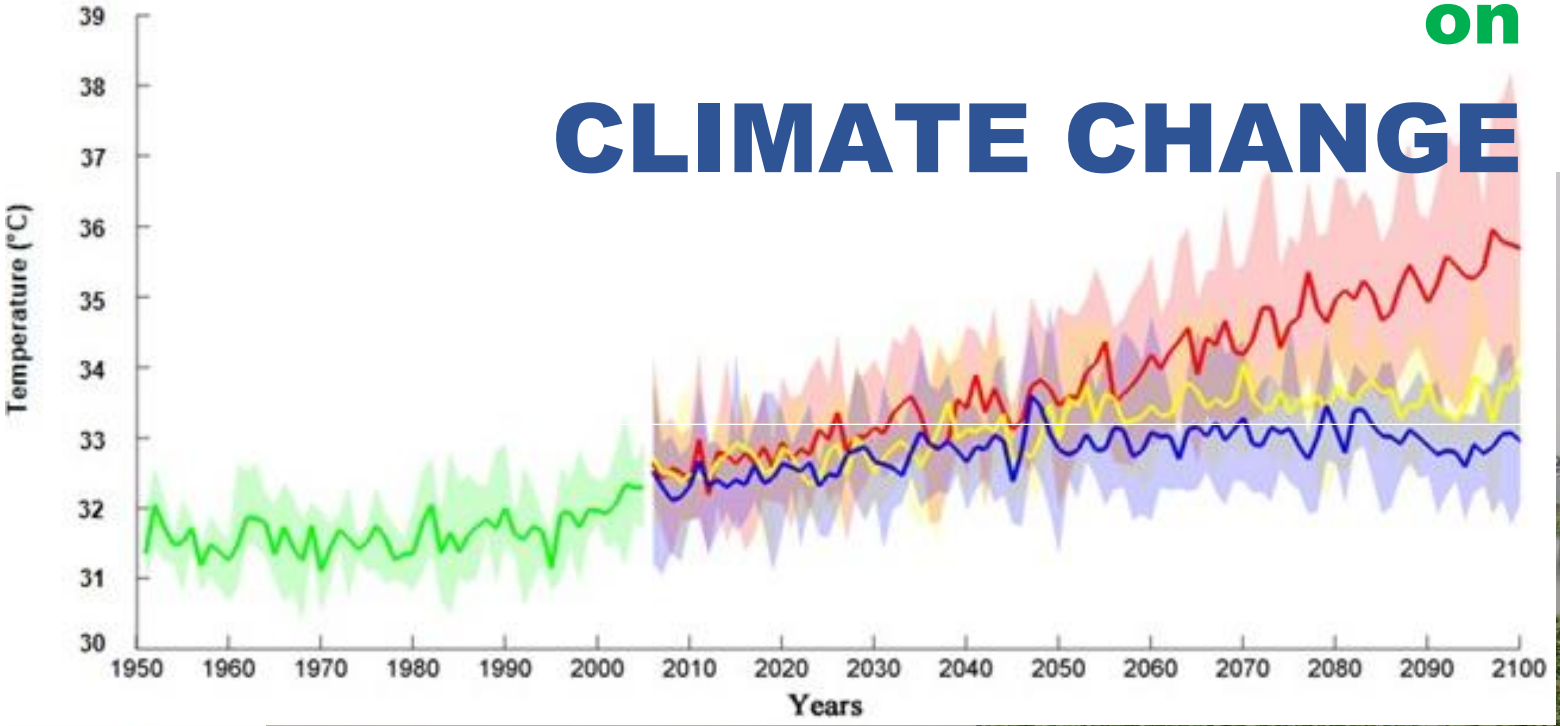
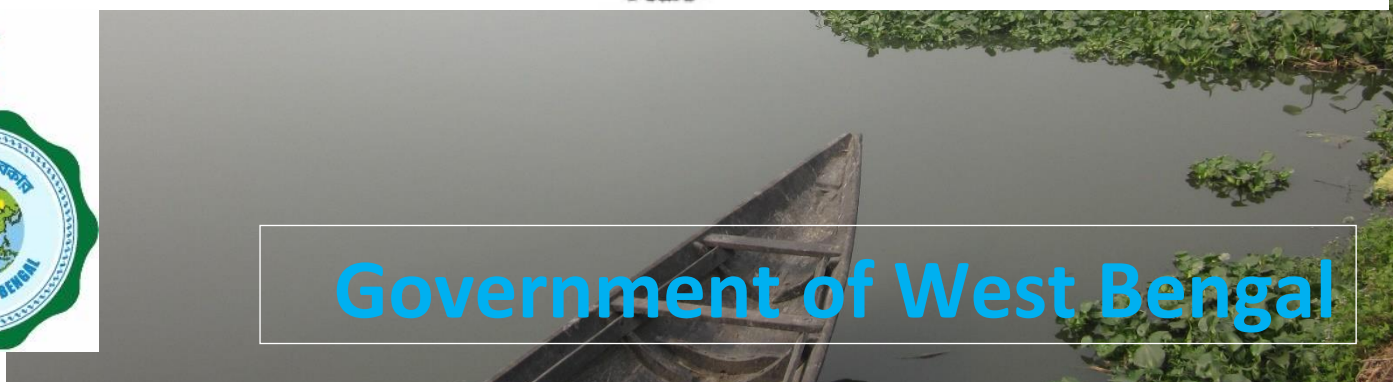
West Bengal
STATE ACTION PLAN
on
CLIMATE CHANGE





Government of West Bengal

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Preface

Climate Change is inducing uncertainty in decision making system through sudden onset of unprecedented temperature rise or intense precipitation within a very short duration, recurrent drought and flood and many such weather extremities. It is essential to design the adaptation plan in intelligent manner to make various manmade infrastructures, agriculture, health care and also natural reserves resilient to climate change. It is also essential to build community resilience across the state.

First State Action Plan on Climate Change was released in 2012. It was essential to review the status after five years and also to analyse the new developments in field of climate change science, technologies, socio-economic conditions and climate politics at international level. An attempt has been made in SAPCC 2017 to summarise updates, enlist new areas of actions and strengthen the mitigation drives.

SAPCC is a live document and each version is aimed to augment the previous version. A project with the title "Fortifying the State Action Plan on Climate Change, West Bengal (SAPCC,WB) for climate proofing and introducing clean energy initiatives" was, therefore, undertaken with support from Future Fund and SAPCC 2017 has been prepared.

All the concerned state governments departments, climate research institutions were consulted during preparation of SAPCC 2017. Active participation has been obtained from the state government departments and the environment department acknowledges co-operation extended by the all stakeholders. The Department of Environment has also obtained field level feedback from farmers at the field and expresses the gratitude for their valuable inputs.

SAPCC 2017 shall also require regular updates and review of status of implementation of action plan from time to time. Successful implementation of SAPCC, 2017 shall lead the state one step forward to " *Build a climate change resilient and carbon neutral West Bengal*".

(Arnab Roy)

List of Abbreviations

CAGR: Compound Annual Growth Rate
CCARI: Climate Change Adaptation in Rural India
CESC Limited: Calcutta Electricity Supply Corporation Limited
CRIS: Centre for Railway Information Systems
CNG: Compressed Natural Gas
COP: Conference of Parties
CORDEX: Coordinated Regional Downscaling Experiment
CSTC: Calcutta State Transport Corporation
CTC: Calcutta Tram Company
DALY: Disability Adjusted Life Years
DHI: Department of heavy Industries, Government of India
DoE: Department of Environment
DPL: Durgapur Projects Limited
DRCSC: Development Research Communication & Service Centre
DVC: Damodar Valley Corporation
ECBC: Energy Conservation Building Code
EV: Electric Vehicle
FAME: Faster Adoption and Manufacturing of Electric and Hybrid Vehicles
GMM-DI: Gaussian mixture model-based drought index,
GCM: Global Circulation Model
GoWB: Government o West Bengal
GSDP: Gross State Domestic Product
HEL: Haldia Energy Limited
HMM-DI: hidden Markov model-based drought index
IIT: Indian Institute of Technology
IITM: Indian Institute of Tropical Metereology
IMD: Indian Meteorological Department
IMR: Infant Mortality Rate
IPCL: India Power Corporation Limited
IPT: Intermediate Public Transport
MoEF&CC: Ministry of Environment, Forest and Climate Change
IPCC: Intergovernmental Panel for Climate Change
IPC: Irrigation Potential Created
IPU: Irrigation Potential Utilized
IPDS: Integrated Power Development Schemes
IWT: Inland Water Transport
KCC: Kisan Call Centre
KMC: Kolkata Municipal Corporation
kWh: Kilowatt Hour
LED: Light Emitting Diode

LCT: Load Carriage Traffic
LMT: lakh Metric ton
MNRE: Ministry of New and Renewable Energy
MRV: Monitoring, Reporting and Verification
NAAQ: National Ambient Air Quality
NABARD: National Bank for Agriculture and Urban Development
NHPC: National Hydroelectric Power Corporation
NMW: National Water Mission
NAFCC: National Adaptation fund under Climate Change
NDC: Nationally Determined Contributions
NTPC: National Thermal Power Corporation
PWD: Public Works Department
RFID: Radio-Frequency Identification
RCP: Representative Concentration Pathways
SAPCC: State Action Plan for Climate Change
SPEI: Standardized Precipitation-evapotranspiration Index
SPI: Standard Precipitation Index
SST: Sea Surface Temperature
SRI: System of Rice Intensification
STU: State Transport Undertakings
TERI: The Energy and Resources Institute
TPWS: Train Protection & Warning System
TWS: Total Water Storage
U&MA: Urban and Municipal Affairs Department
UNFCCC: United Nations Framework Convention for Climate Change
UNSDG: United Nations Sustainable Development Goals
ULBs: Urban Local Bodies
WB: West Bengal
WBECBC: West Bengal Energy Conservation Building Code
WBGEDCL: West Bengal Green Energy Development Corporation Limited
WBPDCL: West Bengal Power Development Corporation Limited
WBREDA: West Bengal Renewable Energy Development Agency
WRIDD: Water Resources Investigation & Development Department
WBSoE: West Bengal State of Environment
WBSEDCL: West Bengal State Electricity Distribution Company Limited
WBSTC: West Bengal Surface Transport Corporation

1.0 Background Information

The State Action Plan on Climate Change (SAPCC), West Bengal was prepared in 2012. Since then, the science of climate change has progressed significantly. The SRES (Special Report on Emission Scenario) scenarios have been superseded by Representative Concentration Pathways (RCPs). RCPs have been used in IPCC's 5th Report AR5 (IPCC, 2014). New global climate projections, which are presented in the AR5 report, are based on four Representative Concentration Pathways (RCPs), namely, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5. The numbers at the end of each RCP represent radiative forcing in Watts/m^2 that will occur by 2100 due to enhanced concentration of greenhouse gases in the atmosphere, leading to a warming ranging between a minimum of average 2^{o}C to a maximum of 4.8^{o}C. It is clear that both Annex-1 and non-Annex 1 Parties to the UNFCCC need to put in their joint efforts to contain the global temperatures within 1.5^{0}C-2^{o}C by 2100 so as to avoid cataclysmic changes in climate resulting in dangerous impacts on our natural resource base on which our food security and economies are thriving.

In response to newer scientific findings, political and administrative authorities are also setting more specific targets to opt for 2050 pathways. The *Paris Agreement*[1] ratified in 2016 legally binds all Parties to the UNFCCC to formulate, pursue and strengthen Nationally Determined Contributions (NDC) for fighting global warming. India has prepared and communicated its NDCs for the period 2021-2030 to UNFCCC in 2015, central to which is its sustainable development agenda, particularly eradication of poverty coupled with its commitment to follow a low carbon path with unencumbered availability of clean technologies and financial resources.

At this juncture, in view of West Bengal's vulnerability and the developments in climate policy nationally and internationally, it is felt necessary to fortify the SAPCC, WB based on the experiences gathered during realization of SAPCC, 2012 and new scientific outcomes and changed political scenarios. The Department of Environment, the nodal department for climate changes in West Bengal, therefore, has undertaken the following initiatives:

- commissioned development of climate projections based on the new RCPs and downscaled climate outputs at regional scale obtained through Coordinated Regional Downscaling Experiment (**CORDEX**) to understand the implications, if any, on the overarching adaptation strategies suggested in the WBSAPCC.
- started reviewing the fulfilment of actions that had been suggested as a part of the strategies of the WBSAPCC to address climate change with a view to show case the achievements.
- started prioritizing small sustained steps. Because, such steps are easier to monitor and can lead to achievement of big goals without losing the objective. The department has decided to elaborate actions, which are implementable, which can be completed within a short time span and, which can be monitored, reviewed and verified (MRV) relatively easily. Therefore, to begin with, it has requested other departments to submit their respective action plan only till 2020.

[1] Paris Agreement, 2015

- taken up initiatives for aligning the Climate Change Action Plan along India's NDCs and as a result includes achievable mitigation actions which will be towards reducing the emission intensity of its own GSDP as well.

The department intends that the West Bengal SAPCC will be the driver, enabling the state to attain Goal 13 of the Sustainable Development Agenda-2030 that calls for urgent action to combat climate change and its impacts, thus enabling West Bengal to attain its 2030 vision of becoming a Carbon Neutral State.

1.1 What's new in SAPCC 2017?

- Summary achievements of implementation of SAPCC 2012
- Downscaling the Global Circulation Model (GCM) Projections at 0.25x0.25 degree resolution
- …. *projections of temperature and annual rainfall at district level at decadal scale*
- Prioritization of Adaptation Strategies for 2018-2020 on basis of latest scientific information
- Introduction of Cleaner Energy Initiatives

1.2 Justification for SAPCC review

- New scientific findings are available and it is essential to re-orient the adaptation strategies with newer updates.
- Global techno-economic scenario is rapidly changing
- A review of status of implementation of SAPCC shall enable the state government to prioritize and strengthen the action programs in present context
- World has reached a consensus in COP 22 for driving mitigation measures and it was state has also initiated actions.

1.3 Methodology Followed

- Regular written communications and interactions with stakeholders,
- Review of reports and records
- Regular Interactions with IITM, Pune, IMD and Climate Scientists and hydrologists of other reputed institutes like IITs
- Meeting of SAPCC steering committee under the chairmanship of Chief Secretary, Government of West Bengal
- Conducting Capacity Building Workshops
- Obtaining views from national and international community through a Webinar

A full-fledged project has been taken up on "**Fortifying the State Action Plan on Climate Change, West Bengal" (SAPCC, WB) for climate proofing and introducing clean energy initiatives, with fund support from the Future Fund – a state and regional alliance under The Climate Group.** It is also essential to have a brief but a closer look towards the profile of West Bengal before going through the summary of work update on this project.

2.0 State Profile of West Bengal

West Bengal is one of the 29 States in India, lying in the eastern part of the country, between 20° 30' N to 27° 16' N latitude and 85° 50' E and 89° 52' E longitude, covering an area of 88,752 sq km. It has only 2.7% of the total landmass of the country. The State is divided into 23 administrative districts and has international borders with Bangladesh, Nepal and Bhutan and has common boundaries with the States of Odisha, Jharkhand, Bihar, Sikkim and Assam. It has a high population densities of 1,028 persons/sq km as against the national average of 382 persons/sq km (Census 2011).

West Bengal covers from its north to South Hill Region, Old Alluvial Zone, New Alluvial Zone, Red and Laterite Zone and the Saline Coastal Region with diverse climates that varies from alpine in the Himalayan districts of Darjiling and Kalimpong to tropical climate in the middle and in the southern part of the state. The southern part of the State is bounded by the Bay of Bengal and the coastline extends for 157 kms. The State is endowed with 3 main rivers, namely, the Ganga, Brahmaputra and Subrnarekha with about 39 sub basins. These rivers are subjected to regular floods as the State receives on an average more than 1,200 mm of rainfall annually, which goes up to 2,000 mm during monsoon.

One of the challenges that West Bengal faces is its population. During the last six decades, the growth of population has not only increased the density in this State but has also put enormous pressure on its natural resources. Demands for natural resources for mere survival are threatening the State's soil quality, water reserves, rich biodiversity and also the ambient conditions. Like the rest of the world, this state is also facing the pressure of rapid urbanization, which often compromises environmental issues. Table 2.1 provides a cursory glance at the state profile vis-a-vis that of India.

Table 2.1: Key socio-economic, physiographic and natural resource profile of West Bengal

Parameter	West Bengal	India
Number of Districts (2016)[1]	23	640
Number of Blocks (2011)[1]	341	6,612
Gross State Domestic Product at constant prices (2014-15)[2]	₹3,98,387 Cr	106.44 lakh crore
Per Capita Income (2014-15) at constant prices (2011-12)[2]	₹38,624	₹74,193
Share of Primary Sector in GSDP[2]	24.87%	18.7%
Share of Secondary Sector in GSDP[2]	14.93%	31.7%
Share of Tertiary Sector in GSDP[2]	60.19%	49.6%
Population (2011)[3]	91.28 million	1.247 billion
Population Density (2011)[3]	1,028 per km^2	382 per km^2
Urban Population(2011)[3]	31.38%	31.16%
Rural Population(2011)[3]	68.62%	68.84%
Life Expectancy at Birth (2011-15)[4]	70.7 years	66.90 years

Parameter	West Bengal	India
Number of Health Units (2015)[1]	13,859	-
Literacy Rate (2011)[3]	76.3%	74%
Number of Schools (2014-15)[5]	64,970	-
Number of Colleges (2014-15)[6]	1,125	-
Employment[7]	38.08%	35%
Cultivators[7]	14.71%	9.3%
Agricultural Laborers[7]	29.32%	9.5%
Household Industry Workers[7]	7.09%	-
Land Area[3] (km^2)	88,752	32,87,000
Forest Area (2014-15)[2]	13.5%	7,01,763
Cultivable Area (2014-15)[2]	65.14%	286,613
Area not available for cultivation, excluding forests[2]	21.33%	638518
Number of Mines[7]	121	-
Installed Power Generation Capacity (2014-15)[8]	12,679.61 MW	329,226 MW
Energy Generated (2014-15)[8]	66,149.35 MU	1,048,673 MU
Number of Registered Factories (2015)[9]	17,636	-
Estimated length of Road (2015)[10]	17,253 km	5,472,144 km
Average annual Rainfall[7]	1,795mm	
Flora[7]	> 6,000 species	
Fauna[7]	>11,000 species	
Total River Basin Area[7]	88,752 km^2	
Number of main rivers	3	22
Number of sub basins[11]	39	
Coastal length	157.5 km	
Annual Surface Water Available[7]	77.06 bcm	
Annual Replenishable Ground Water availability[7]	31.72 bcm	

Source:

[1] Statistical Abstract 2015

[2] Bureau of Applied Economics & Statistics, GoWB

[3] Directorate of Census Operation, West Bengal

[4] Office of the Registrar General, GoI,

[5] Paschim Banga Sarva Shiksha Mission

[6] Department of Higher Education, GoWB

[7] State of Environment Report, West Bengal, 2016

[8] Department of Power and Non-Conventional Energy Sources, GoWB

[9] Chief Inspector of Factories, West Bengal

[10] Public Works (Roads) Department, GoWB,

[11] WRIDD. Flood Report 2016

A district wise map of West Bengal is provided in Figure 2.1. The map provides an idea about the districts and its locations within West Bengal.

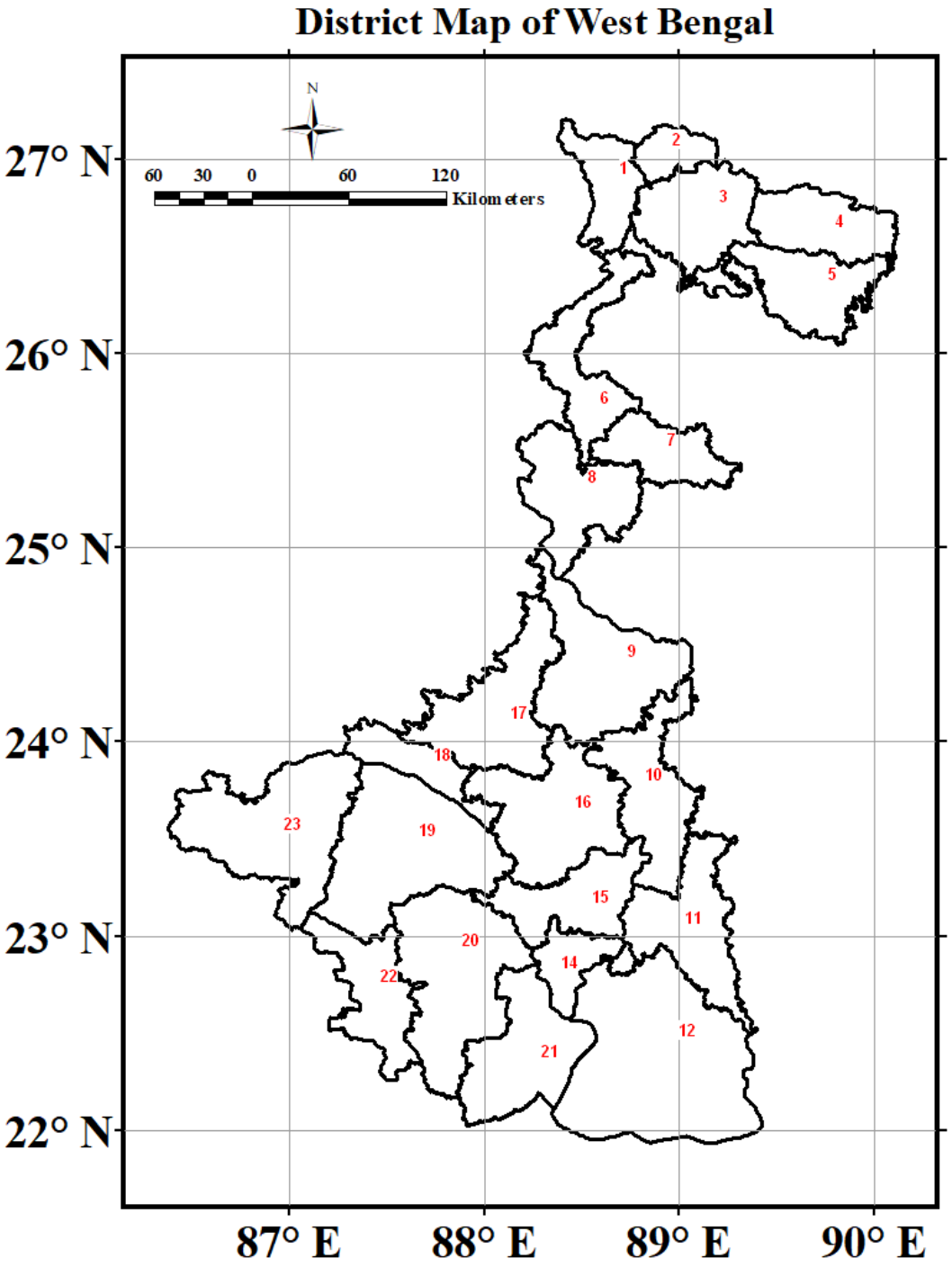


Figure 2.1 District wise map of West Bengal

Index for Figure 2.1

1	DARJILING
2	KALIMPONG
3	JALPAIGURI
4	ALIPURDUAR
5	KOCH BIHAR
6	UTTAR DINAJPUR
7	DAKSHIN DINAJPUR
8	MALDAH
9	MURSHIDABAD
10	NADIA
11	NORTH 24 PARGANAS
12	SOUTH 24 PARGANAS
13	KOLKATA
14	HAORA
15	HUGLI
16	PURBA BARDDHAMAN
17	BIRBHUM
18	PASCHIM BARDDHAMAN
19	BANKURA
20	PASCHIM MEDINIPUR
21	PURBA MEDINIPUR
22	JHARGRAM
23	PURULIYA

3.0 Observed Climate and New Projections

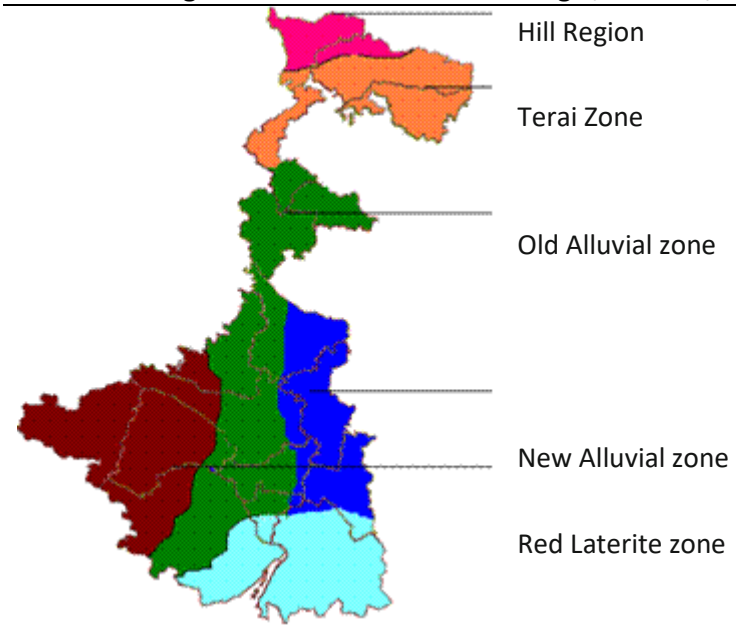
In parlance of climate change, the time period considered for any analysis is extremely crucial for understanding the output of various studies. Trend lines estimated from a shorter duration may grossly vary from trend line estimated from different segments of a timeline or from a longer time period. Interferences drawn from study of different time periods even from same authentic source like IMD is, therefore, needed to be understood with great care . An effort has been made in the following paragraphs to bring out principal observations about temperature and total annual rainfall from the studies made by using different time periods.

3.1 Observed Trends

3.1.1 Temperature

West Bengal has 6 agro-climatic zones, namely the Hill zone, Terai zone, Old alluvial Zone, New Alluvial zone, Red and laterite zone and coastal and saline zone. The details of coverage of these zones, locations, physiography and climate are indicated in Table 3.1. The average temperature in West Bengal ranges between a minimum of 8.4^{o}C in the Hilly region to a maximum of 37^{o}C in the red and laterite zone. The rainfall varies from a minimum of 1100 mm in the red and laterite zone to a maximum of 3500 mm in the hilly region.

Table 3.1: The agro-climatic zones of West Bengal, location, coverage, soil and weather



Agro Climatic Zones	District	Description and *GSM weather station*[i]
Hill region (2.4-8 lakh ha)	Hilly areas of Darjiling district	Terraced, brown forest, shallow, highly acidic (pH 4 to 6), moderately fertile soil. Temperature range: 8.9 to 14.9 °C Annual rainfall: 3,550 mm ***Darjiling***
Terai Zone (2.15 ha)	Remaining area of Darjiling district, Koch Bihar and Jalpaiguri, Kalimpong and Alipurduar	Sandy to Sandy loam soil. Temperature range: 12.8 to 32.3 °C Annual rainfall: 2,000 to 3,500 mm ***Koch Bihar, Jalpaiguri***
Old Alluvial Zone (17.54 ha)	North Dinajpur, South Dinajpur and Maldah	Old alluvial zone Mostly flat, Loam, deep, mostly neutral soil. Temperature range: 15.1 to 35.3 °C. Annual rainfall: 1,600–1,800 mm ***Maldah, Balurghat***
New Alluvial Zone (15.30 ha)	Murshidabad, Nadia, 24 N. Parganas, Haora, Hooghly & Burdwan	Flat to rolling, Light to heavy, acidic to neutral (pH 5.7) soil. Temperature range: 15.6 to 35 °C. Annual rainfall:1,200–1,700 mm ***Kalyani, Krishnanagar***
Red Laterite zone Alluvial Zone (24.84)	Birbhum, Bankura, Puruliya, West Medinipur;	Undulating, coarse textured, susceptible to erosion, acidic soil. Temperature range: 14.8 to 37 °C. Annual rainfall:1,100–1,300 mm ***Bankura, Puruliya***
Saline Coastal region (14.57 ha)	East Medinipur, Hooghly, 24 South Parganas, Kolkata	Alluvial, fine textured, saline soil. Temperature range: 16 to 34 °C. Annual rainfall: 1,500–1,700 mm ***Diamond Harbour, Canning***

Analysis of Indian Meteorological Department (IMD) data obtained from 19 surface meteorological stations in West Bengal for the period 1951 and 2010 indicates that there is an increasing trend of $+0.01^0$C per year in the annual mean maximum temperature. However, there is no annual trend in the annual mean and annual mean minimum temperatures. Seasonal trends are noted in Table 3.2 (Rathore et al., 2013[2]). Another analysis[3] of 37 years of IMD data (1969-2005) suggests the changes in

[2] Rathore L S, S D Attri and A K Jaswal, 2013. STATE LEVEL CLIMATE CHANGE TRENDS IN INDIA Meteorological Monograph No. ESSO/IMD/EMRC/02/2013. Published by IMD. Available at: http://www.imd.gov.in/section/climate/StateLevelClimateChangeMonoFinal.pdf

temperature also vary spatially (Table 3.3). Considering that the time period for analyses in Table 3.3 (1969-2005) is a subset of time period for the work carried out by Rathore et al 2013 (1951-2010), the rate of increase in maximum temperature is accepted as $+0.01^0$ C per year for further work in this report. However, the reason for observing no annual trend in mean minimum temperature and mean temperature (Table 3.2) is due to different degree of changes in different seasons and also due to varied degree of climatic responses in the six spatially different agro-climatic zones of West Bengal, which is apparent from Table 3.3.

Table 3.2: Temperature Trends in West Bengal between 1951 and 2010[4]

Parameters	Annual	Winter	Summer	Monsoon	Post Monsoon
Mean Max. Temp. Trend (°C/yr)	+0.01	No Trend	-0.01*	+0.02*	+0.02*
Mean Min. Temp. Trend (°C/yr)	No Trend	+0.01*	No Trend	No Trend	+0.01*
Mean Temp. Trend (°C/yr)	No Trend	No Trend	-0.01*	+0.01*	+0.01*

*trends significant at 95% level of significance

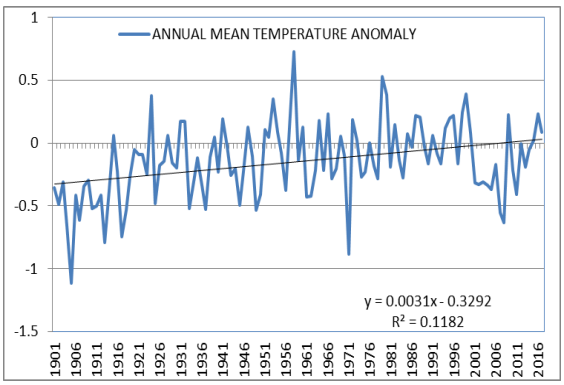
Table 3.3: Change in of Diurnal Difference of Temperature in six agro-climatic zone[ii] between 1969-2005

Change in Zones	Hill zone	Terai zone	Old Alluvial	New Alluvial zones	Laterite zone	Saline Coastal zone
Maximum Temp.	-0.25°C	-0.25°C	-0.25°C	-0.5°C	-0.5°C	-0.5°C
Minimum Temp.	$+1.5^0$C	$+1.5^0$C	$+1.5^0$C	$+1^0$C	+0.5°C	$+1^0$C
Net Reduction in diurnal difference	1.75^0C	1.75^0C	1.75^0C	1.5^0C	1^0C	1.5^0C

An analysis of 116 years of data (1901 - 2016) by IMD again illustrates that all three anomalies for mean temperature, maximum temperature and minimum temperature are showing increasing trends at various rates (Figure 3.1-3.4). During the same period, the trend of all India anomaly of mean temperature also showed an increasing trend (3.4). Spatial analysis by IMD for 116 years of data (1901 to 2016) also shows significant increasing trends of annual mean, annual mean maximum and annual mean minimum temperatures (Figures 3.5, 3.6 and 3.7) for most of the districts of West Bengal, which corroborate the observation that temperature is increasing in West Bengal.

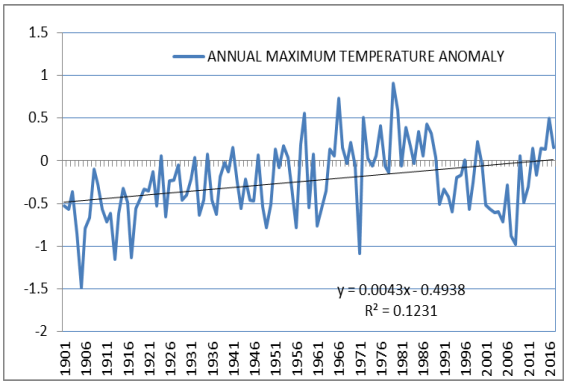
[3] State Action Plan on Climate Change 2012, page 46, http://www.moef.nic.in/sites/default/files/sapcc/West-Bengal.pdf

[4] [4] Rathore L S, S D Attri and A K Jaswal, 2013. STATE LEVEL CLIMATE CHANGE TRENDS IN INDIA Meteorological Monograph No. ESSO/IMD/EMRC/02/2013. Published by IMD. Available at: http://www.imd.gov.in/section/climate/StateLevelClimateChangeMonoFinal.pdf



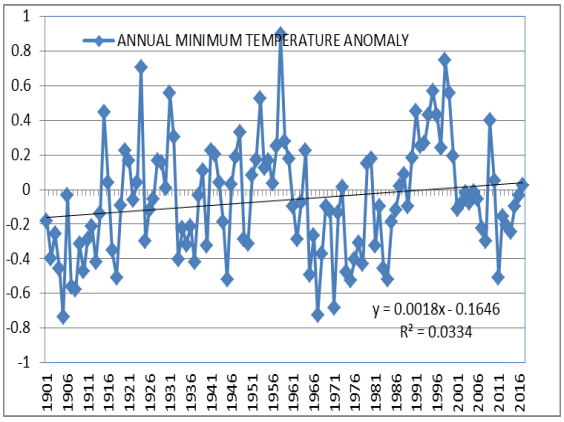
Trend 0.31^{0}C per 100year

Figure 3.1: Annual mean temperature anomaly for 116 yrs



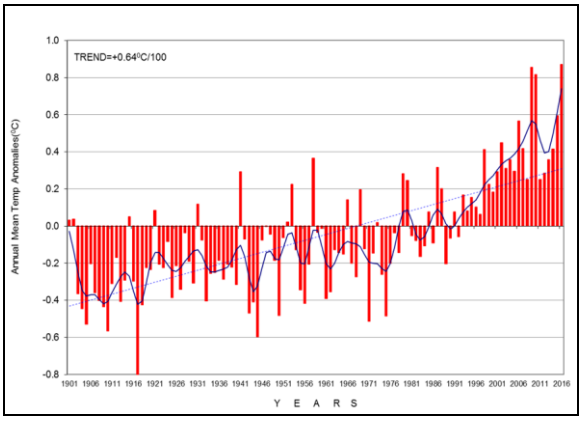
Trend 0.43^{0}C per 100year

Figure 3.2: Annual mean temperature anomaly for 116 yrs



Trend 0.18^{0}C per 100year

Figure 3.3: Annual mean temperature anomaly for 116 yrs



Trend 0.64^{0}C per 100year

Figure 3.4: Annual mean temperature anomaly for 116 yrs

Reference: Presentation by Dr. A K Sahai, Head, Climate Research & Services, IMD, Pune and IITM, Pune on 30.01.2018 at a workshop[5] at Kolkata

[5] Workshop on building a climate change resilient and carbon neutral West Bengal at Kolkata on 30.01.2018

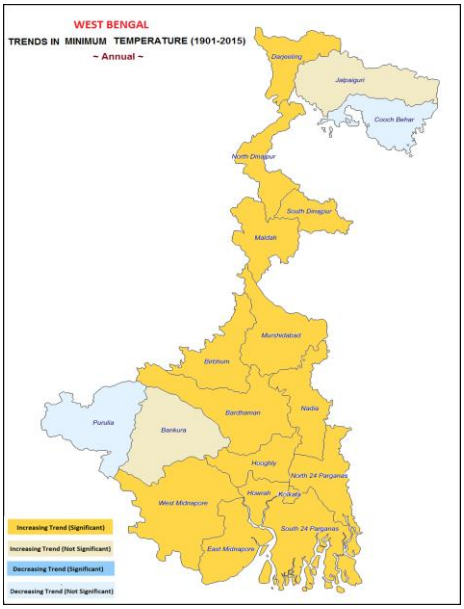


Figure 3.5 : Trends of Annual Minimum Temperature (1901-2015)

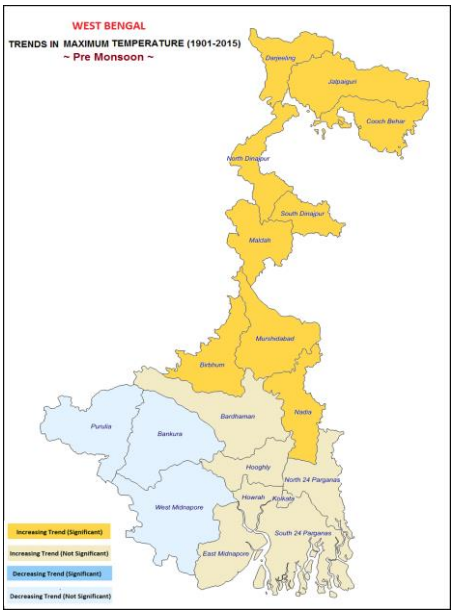


Figure 3.6 : Trends of Annual Maximum Temperature (1901-2015)

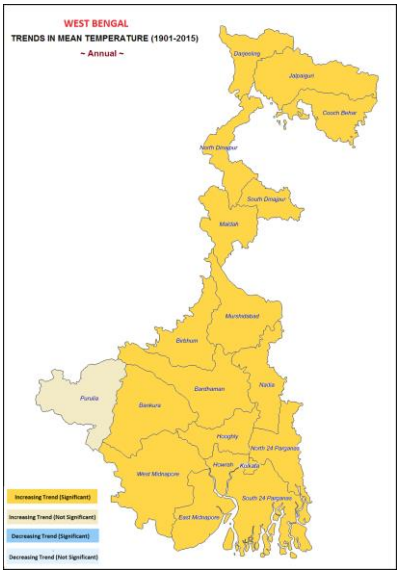


Figure 3.7: Trends of Annual Mean Temperature (1901-2015)

Reference: Presentation by Dr. A K Sahai, Head, Climate Research & Services, IMD, Pune and IITM, Pune on 30.01.2018 at workshop[6] at Kolkata.

The diurnal differences showed similar changes for short term (1969-2005) and long term (1901-2016) year observation except for the Terai region. Information available in section 3.1.1 shows that the West

[6] Workshop on building a climate change resilient and carbon neutral West Bengal at Kolkata on 30.01.2018

Bengal faced warming during 1901 to 2016. However, the degree of warming varied over different regions. The warming trends also varied at different rates in different seasons.

3.1.2 Rainfall

Like many other states in India, the rainfall in West Bengal is primarily governed by the south west monsoon that occurs from June to September. However, the south west monsoon is still considered to be the least studied and least understood phenomena among the six major ocean-atmospheric global circulations. Availability of limited information is a major constraint in conducting detailed study. The available reports suggest that rapid changes are taking place in this region, which needs realtime monitoring. This is discussed in detail in this section.

The south west monsoon rainfall contributes 76.8% of the total annual rainfall in West Bengal. It is highly spatially variable ranging from a minimum of 1200 mm in Red Laterite Zone region in the western part of the state to a maximum of 3500 mm in the Himalayan region (GSM data). However, a decreasing trend in south-west monsoon rainfall has been observed over the Gangetic plains in India (IGP) between 1901-2012 [7]. The IGP covers West Bengal as well. The reasons for decreasing trend in south-west monsoon rainfall is attributed to the rapid increase in SST (Sea Surface Temperature) in the Western Indian Ocean, causing lesser contrast in land and sea temperature.

Figure 3.8 below depicts the observed trends of precipitation in mm/day over 112 years (1901-2012). Figure (a) shows observed trends by IMD and Figure (b) shows CRU Data Sets for Southwest Monsoon Period (June-September) 1901-2012. Contours denote regions significant at the 95% Confidence Level.

[7&8] Mathew Koll Roxy, Kapoor Ritika, Pascal Terray, Raghu Murtugudde, Karumuri Ashok & B. N. Goswami, 2015. Drying Of Indian Subcontinent By Rapid Indian Ocean Warming And A Weakening Land-Sea Thermal Gradient. Nature Communications, 6:7423, Doi: 10.1038/Ncomms 8423. Available At: *http://www.nature.com/ncomms/2015/150616/ncomms8423/full/ncomms8423.html*

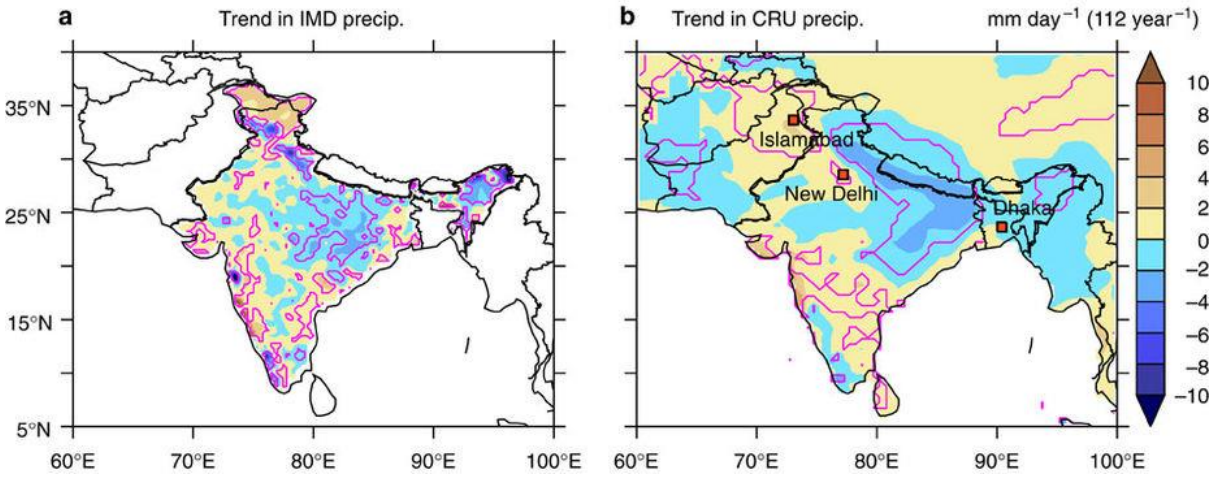


Figure 3.8: Observed Trends of Precipitation in mm/day/112 Years

In the West Bengal region, the IMD observations indicate a decrease by 0-2 mm/day in the south west monsoon pour in the Bardhaman district and to some extent in Uttar Dinajpur district as well. However, the homogenized CRU[8] data available at 0.5° x 0.5° gridded resolution, indicates an overall decrease by 0-2 mm/day in the entire region covering districts like Nadia, North 24 Parganas, Haora, and Purba Medinipur (Figure 3.2)[9].

Indian summer monsoon is governed by different hydrological phenomena:

- Atlantic multidecadal oscillations at multi decadal scale
- El Nino oscillations
- Indian ocean dipole moment at inter annual scale
- Monsoon intra – seasonal oscillations at intra-seasonal scale

Therefore, availability of rainfall changes from one year to other and also within the year. Decadal mean of rainfall for India as a nation shows significant periodicity (Figures 3.9 and 3.10). Figure 3.9 shows that India receives a greater rainfall in La Nina years. Thirty-one year of moving average of seasonal rainfall (1885-2015) shows a clear periodicity.

[8] For CRU (Climate Research Unit Data produced by NCAR). For more see https://climatedataguide.ucar.edu/climate-data/cru-ts-gridded-precipitation-and-other-meteorological-variables-1901

[9]Mathew Koll Roxy, Kapoor Ritika, Pascal Terray, Raghu Murtugudde, Karumuri Ashok & B. N. Goswami, 2015. Drying Of Indian Subcontinent By Rapid Indian Ocean Warming And A Weakening Land-Sea Thermal **Gradient. Nature Communications, 6:7423, Doi: 10.1038/Ncomms 8423. Available At:** ***http://www.nature.com/ncomms/2015/150616/ncomms8423/full/ncomms8423.html***

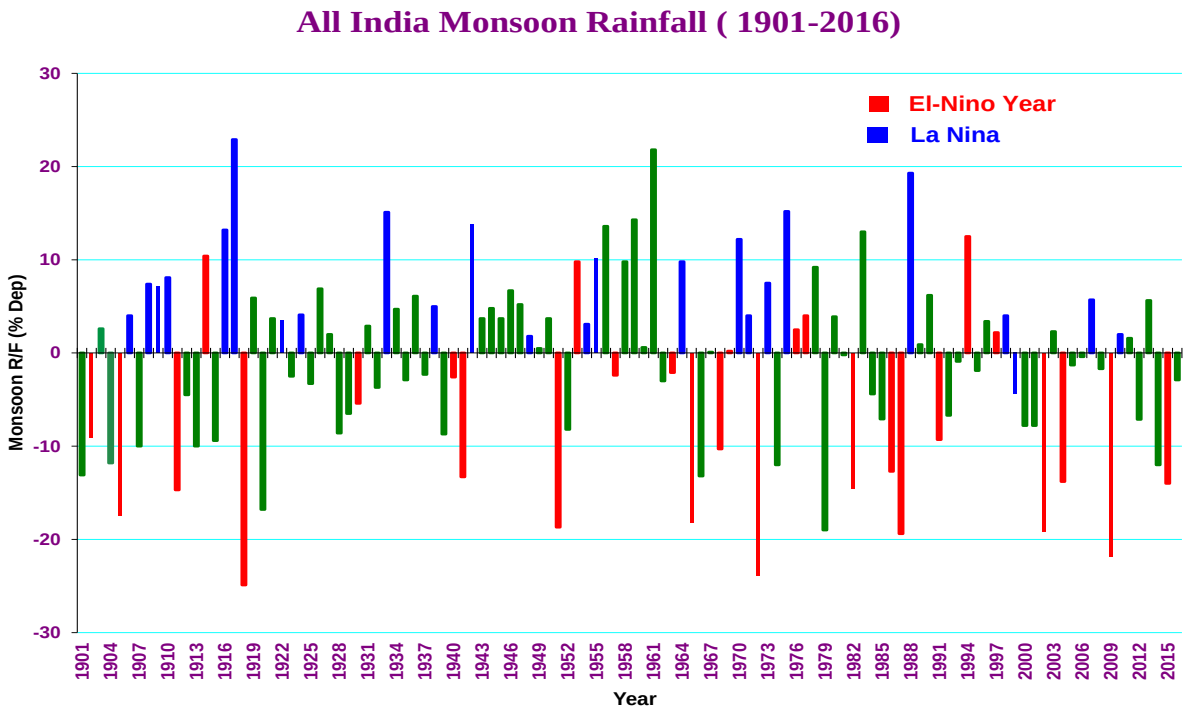


Figure 3.9 Indian Summer Monsoon is significantly influenced by El-Nino and La Nina Phenomena

Reference: Presentation by D.R. A.K.Sahai, Head, Climate Research & Services, IMD, Pune and IITM, Pune on 30.01.2018 at workshop10 at Kolkata

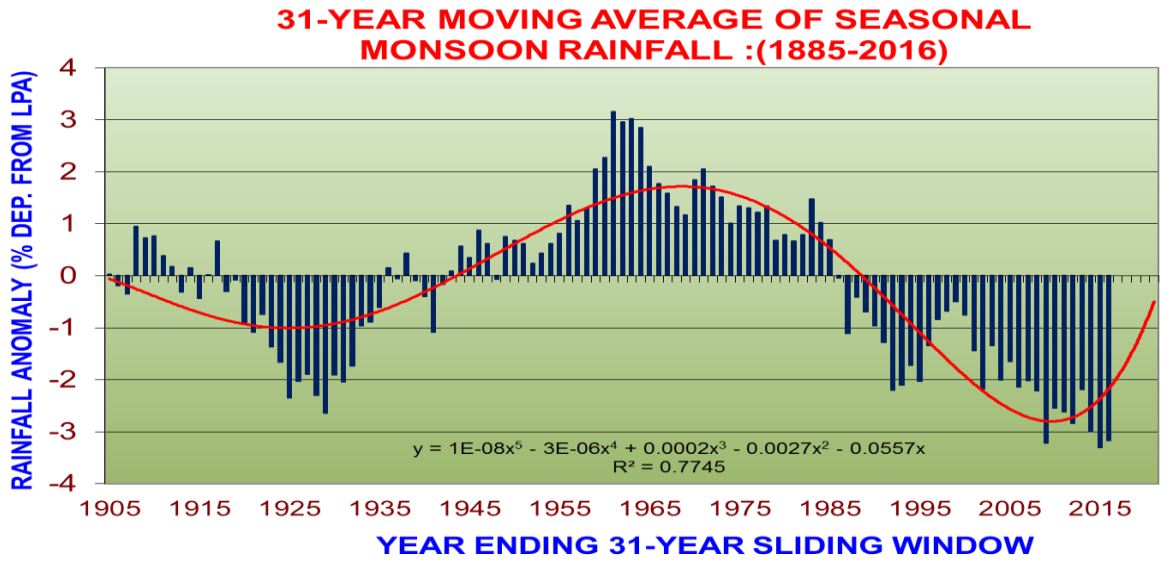


Figure 3.10: Availability of rainfall shows variability and availability of less rainfall during 1885-2015

[10] Workshop on building a climate change resilient and carbon neutral West Bengal at Kolkata on 30.01.2018

Reference: Presentation by Dr. A K Sahai, Head, Climate Research & Services, IMD, Pune and IITM, Pune on 30.01.2018 at workshop11 at Kolkata

Although, such variability also influences the rainfall in West Bengal (Figure 3.11) but the pattern is significantly different over decades compared to the national level.

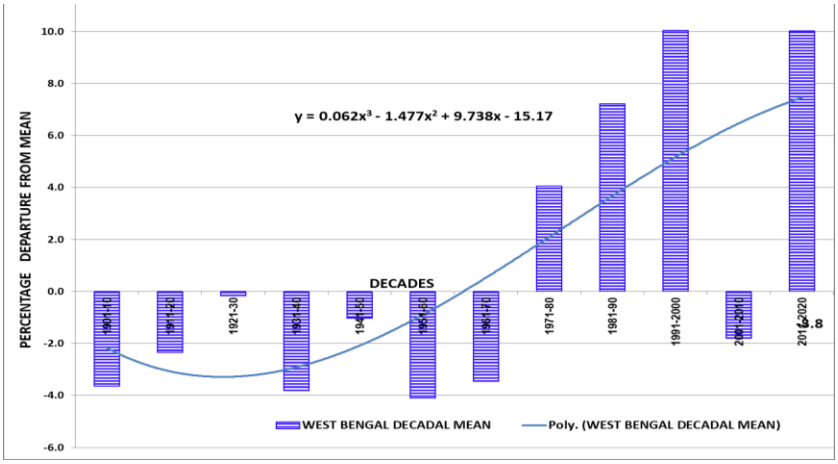


Figure 3.11 Departure (in Percentage) of rainfall from the decadal means during 1901-2016

Reference: Presentation by Dr A K Sahai, Head, Climate Research & Services, IMD, Pune and IITM, Pune on 30.01.2018 at workshop[12] at Kolkata.

However, observations of temperature since 2002 indicate a strong warming of the Indian landmass (Figure 3.4). This has again strengthened the thermal contrast between landmass and sea, leading to a revival of the monsoon (Qinjian Jin & Chien Wang, 2017)[13]. This contrast has also led to an increase in the summer monsoon rainfall over most parts of West Bengal from 0.1 to 1.1 mm/day/decade.

[11] Workshop on building a climate change resilient and carbon neutral West Bengal at Kolkata on 30.01.2018
[12] Workshop on building a climate change resilient and carbon neutral West Bengal at Kolkata on 30.01.2018
[13] Qinjian Jin & Chien Wang, 2017, A revival of Indian summer monsoon rainfall since 2002, Nature Climate Change, 7, 587–594

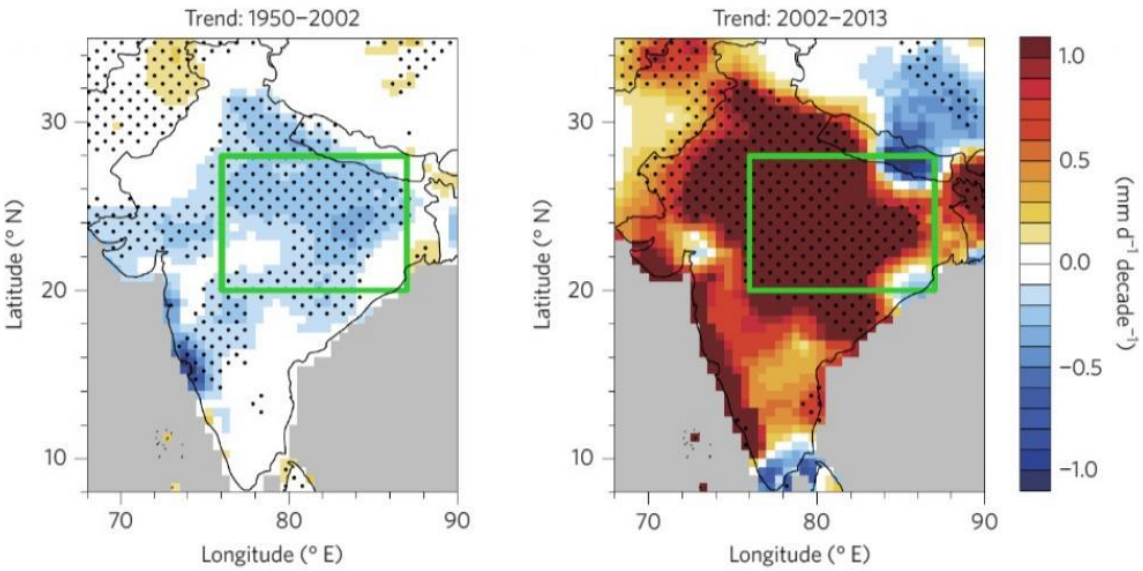
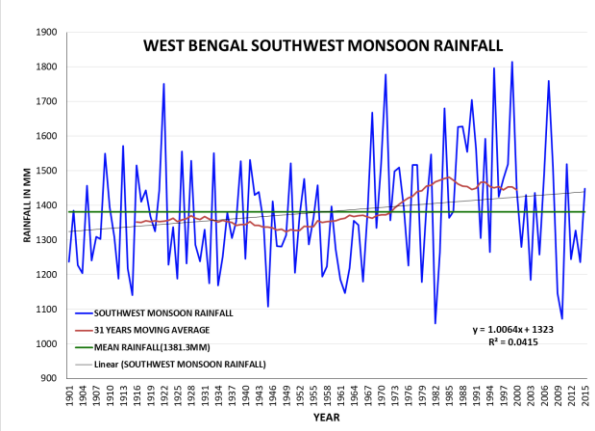


Figure 3.12: Trends of rainfall (a) 1951-2002 and (b) 2002-2013

Source: Qinjian Jin & Chien Wang, 2017

Figure 3.13 shows although the trendline for rainfall is increasing for 116 year analysis but that state received rainfall less than the mean for six consecutive years during 2011-2016



Rainfall is less than the mean between 2012 to 2016

Figure 3.13: Variation of southwest monsoon during 2011-2016

Reference: Presentation by Dr A K Sahai, Head, Climate Research & Sevices, IMD, Pune and IITM, Pune on 30.01.2018 at workshop[14] at Kolkata

[14] Workshop on building a climate change resilient and carbon neutral West Bengal at Kolkata on 30.01.2018

Historical analysis of rainfall for past 116 years (1901-2016) suggests gross variations in trends across the state. Nine districts - Nadia, Burdawn, Haora, Hugli, Maldah, Jalpaiguri, North and South Dinajpur and Puruliya show decline in rainfall availability. Agriculture is thriving in most of these districts and lack of rainfall is expected to seriously impact their agricultural productivity. Where as, rainfall increased in the coastal districts like South 24 Parganas, East Midnapur and West Midnapur, which resulted into increase in flooding situations.

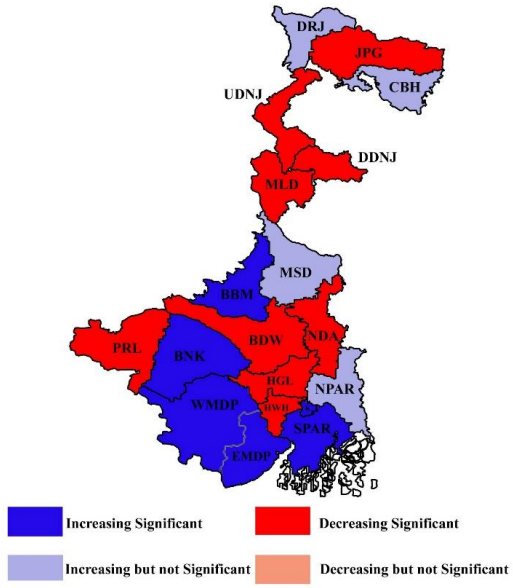


Figure 3.13a: Different Trends of rainfall for different districts[15]

Note: [DRJ: Darjiling, JPG:Jalpaiguri, CBH: Coochbohar, BDW : Burdwan, NDA: Nadia, HGL: Hugli, HWH: Haora, PRL: Puruliya, MLD: Maldah, UDNJ : North Dinajpur, DDNJ: South Dinajpur, NPAR: North 24 Pargana, SPAR: South 24 Pargana, EMDP: East Midnapur and WMDP West Midnapur, BNK: Bankura, BBM: Birbhum]

Rainfall distribution is skewed over West Bengal temporally. Rainfall is showing opposite trends in neighboring districts, which invokes for introduction of more flexibility in adaptation strategies. So that the drought scenario for one district and flood situation for adjacent districts can be handled at the same time with equal preparedness.

[15]Presentation by Dr. A K Sahai, Head, Climate Research & Sevices, IMD, Pune and IITM, Pune on 30.01.2018 at workshop15 at Kolkata

Section Summary: The trend of rainfall may vary with time scale. The long term trends may show increasing trend but last five year trend may show steady decline because of significant inter annual variability and changes in climatic forcing.

Parts of the state faced heavier rain and flood conditions while remaining areas faced drought or scanty rainfall during the last 116 years.

Even same district faced flood and drought in same year.

3.1.3 Extreme events

Rainfall: Further a study by Goswami et al[16], suggests significant rising trends in the frequency and magnitude of extreme rain events and a significant decreasing trend in the frequency of moderate events over central India during the monsoon seasons from 1951 to 2000 and more intense rain fall events over the central Indian region and in some parts of West Bengal (Northern parts of West Bengal including the Himalayan region and the southern part , which has the Sundarbans region).

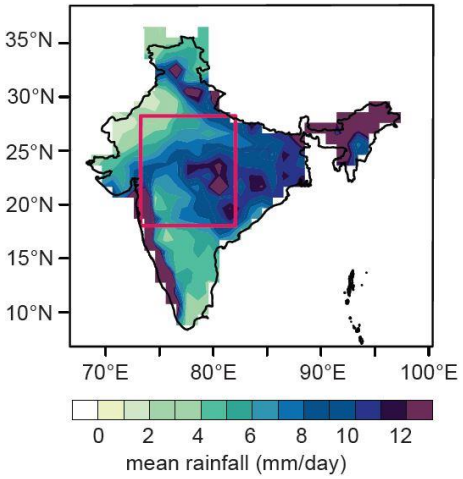


Figure 3.14: Trends of extreme rainfall events in India during 1951-2000[17]

Source: Goswami et al., 2006

It may be summarized that although the total rainfall is decreasing but extreme weather events are increasing due to new occurrence of sharp gradient between land surface temperature and SST (Sea Surface Temperature). The differences presented by different studies may also be attributed to the low weather monitoring stations of this region.

[16] Goswami, B. N. *et al*. Increasing trend of extreme rain events over India in a warming environment. *Science* **314**, 1442-1445 (2006)

[17] Goswami, B. N. *et al*. Increasing trend of extreme rain events over India in a warming environment. *Science* **314**, 1442-1445 (2006)

Cyclones: West Bengal had 69 occurrence of cyclones between 1891 and 2013 (Mishra, 2014)[18]. Studies (Mooley, 1980[19]; Rao, 2002[20]; Knusten and Tuley, 2004[21]; Emanual, 2005[22]; Landsea, 2005[23]; IPCC, 2007[24]; and Muni Krishna , 2009[25]; and Yu and Wang [26]) have shown that though the occurrence of tropical cyclones is declining but the frequency of severe cyclonic storms with wind speeds between 118-167 kmph is increasing noticeably. This has been attributed to rising sea surface temperature. The occurrences of extreme weather conditions during 2013-2017 is shown in Table 3.4.

Table 3.4: Occurrences of Extreme Weather events, which affect health in last five years:

Weather events	**2013**	**2014**	**2015**	**2016**	**2017**
Cold Wave:	January 8th to January 26th, 27th 29th & 30th. February 10th November 16th	February 2nd, 3rd , 18th	January 31st, February 1st , December 25th	January 24th & 25th	January 15th & 16th
Heat wave	April 9th to 11th & 14th May 2nd & 3rd	March 29th to 31st, April 1st, 24th to 30th, May 9th, 12th to 23rd, June 12th to 16th	May 22nd to 24th, June 8th to 11th	April 7th to 17th, 20th, 30th, May 1st	March 31st and April 3rd
Nos. of cyclones			Cyclone 'Komen' during 31st July to 1st		

[18] Mishra Ashutosh, 2014. Temperature Rise and Trend of Cyclones over the Eastern Coastal Region of India. J Earth Sci Clim Change 2014, vol 5, Issue 9.
[19] Mooley DA (1980) Severe cyclonic storms in the Bay of Bengal, 1877-1977. Mon Wea Rev 108: 1647-1655. 7.
[20] Rao YR (2002) The Bay of Bengal and tropical cyclones. Curr Sci 82: 379-381.
[21] . Knutson TR, Tuleya RE (2004) Impact of CO2 -induced warming on simulated hurricane intensity and precipitation: sensitivity to choice of climate and convective parameterization. J Climate 17: 3477-3495.
[22] Emanuel K (2005) Increasing destructiveness of tropical cyclones over the past 30 years. Nature 436: 686-688.
[23] Landsea CW (2005) Hurricanes and global warming. Nature 438: 11-13.
[24] IPCC (2007) Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.
[25] Muni Krishna K (2009) Intensifying tropical cyclones over the North Indian Ocean during summer monsoon – Global warming. Global Planetary Change 65: 12-16.
[26] Yu J, Wang Y (2009) Response of tropical cyclone potential intensity over the north Indian Ocean to global warming. Geophy Res Let 36

Weather events	2013	2014	2015	2016	2017
			August over Gangetic West Bengal		
No. of episode of floods (Based on media report as IMD is only issuing heavy forecast & warning)	July 21st to 31st in Gangetic West Bengal August 8th to 14th in North Bengal	July 24th & 25th over North Bengal, August 23rd to 25th over Haora & Hooghly district	July 29th to 31st over Haora, Puruliya Burdwan, Bankura, South 24 Pargana, Jalpaigurhi August 1st to 4th over Haora, Burdwan, east and West Midnapore, Bankura, North and South 24 parganas, Nadia, Puruliya, Hooghly, Birbhum	NIL	July and August , 2017 in North Bengal

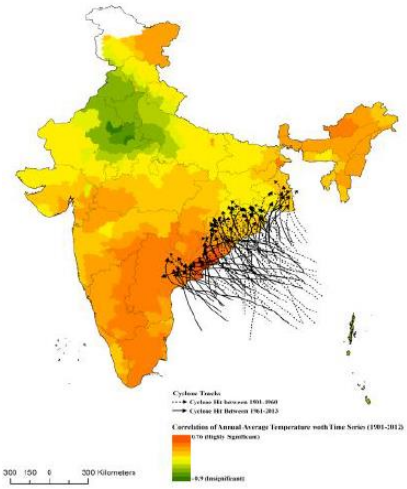


Figure 3.15: Cyclone Tracks Along The Bay Of Bengal Entering The East Coast Of India during 1901-2013
Source: Misra, 2014[9].

Droughts: A Study by Mallaya et al. (2016)[27] of drought characteristics for the Indian monsoon region analysed using two different datasets (IMD daily gridded precipitation data set at 1° resolution and University of Delaware/NOAA monthly precipitation data set at 0.5° spatial resolution) and standard precipitation index (SPI), standardized precipitation-evapotranspiration index (SPEI), Gaussian mixture model-based drought index (GMM-DI), and hidden Markov model-based drought index (HMM-DI) for the period 1901–2004, indicates that irrespective of the precipitation datasets and methodology used, the droughts appear to be migrating to the agriculturally important regions such as the Indo-Gangetic plains (of which West Bengal is a part) in recent years implying higher food insecurity and socio-economic vulnerability of this region.

Other Hazards: West Bengal across its various physiographic regions is annually experiencing landslides, floods, droughts, storm surges, because of which large scale damages are reported in terms of area inundated, crop loss, livestock and human mortalities, nutritional deficiencies, increase in DALY's (Disability Adjusted Life Years), as well as housing, tele-communication networks, electricity distribution systems and other infrastructure including roads, embankments and river banks. The level of impacts and hence damages are likely to escalate as rainfall, temperature, droughts, storm surges intensify and sea levels rises[28].

[27] Ganeshchandra Mallyaa, Vimal Mishra, Dev Niyogi, Shivam Tripathi, Rao S. Govindaraju, 2016. Trends and variability of droughts over the Indian monsoon region. Weather and Climate Extremes. Vol.12, pg 43-68. Elsivier open access journal. Available at: https://www.sciencedirect.com/science/article/pii/S2212094715300578

[28] IPCC, 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf

3.2 Climate Projections

New climate projections have been made using the downscaled regional model (CMIP) outputs of the CORDEX experiment driven by 4 GCMs (Global Circulation Models) (CNRM-CM5, GFDL-ESM-2M, MIROC5 and MPI-ESM-LR) and forced by the new scenarios RCP 2.6, RCP 4.5 and RCP 8.5 – the probable scenarios that can contain the global temperatures rise below 2°C. This activity has been carried out by IIT Mumbai.

The analysis projects significant increase in maximum and minimum temperatures and decrease in precipitation till 2100 over West Bengal (Figures 3.16 to 3.18). For the near future (2021-2030), the average maximum temperature is projected to rise by +1 to +1.04°C wrt base line (1961-1990) for the concentration pathways RCP 2.6 and RCP 4.5 respectively (Table 3.5). The minimum temperature is projected to increase by +1.17 to 1.22°C for the same concentration pathways respectively. An overall decrease in precipitation is projected over West Bengal by -8.98% for RCP 2.6 and by -10.91% for RCP 4.5 and for RCP 8.5 -22.23 % w.r.t the base line simulation (1961-1990). However, 30 year mean annual precipitation projections for RCP 2.6 indicate that the maximum rainfall may increase by 1 mm per day for Darjiling- Jalpaiguri.

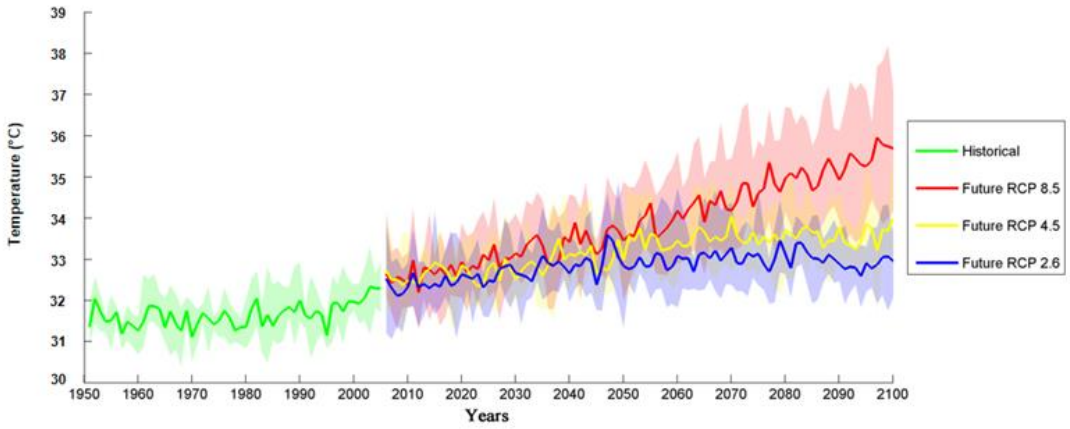


Figure 3.16: Simulated (1951-2010) and projected (till 2100) average annual maximum temperature trends in West Bengal

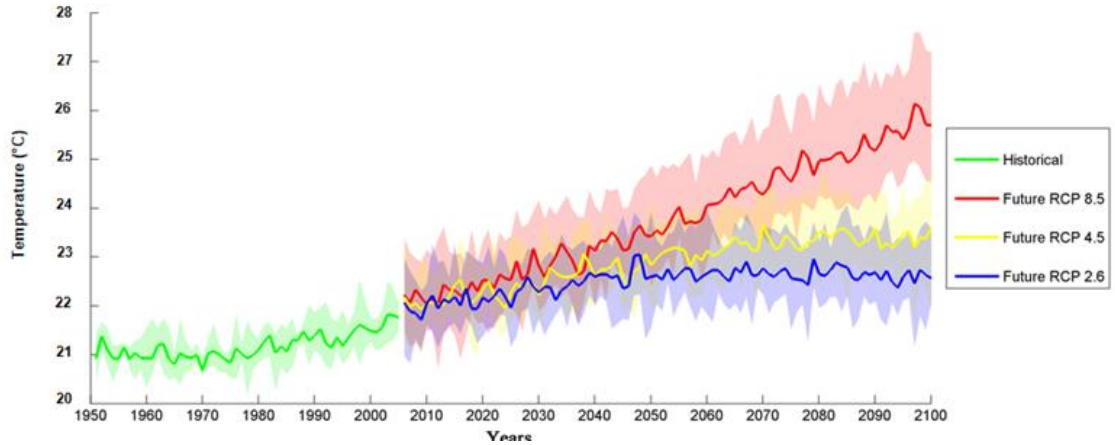


Figure 2.17: Simulated (1951-2010) and projected average annual minimum temperature trends in West Bengal

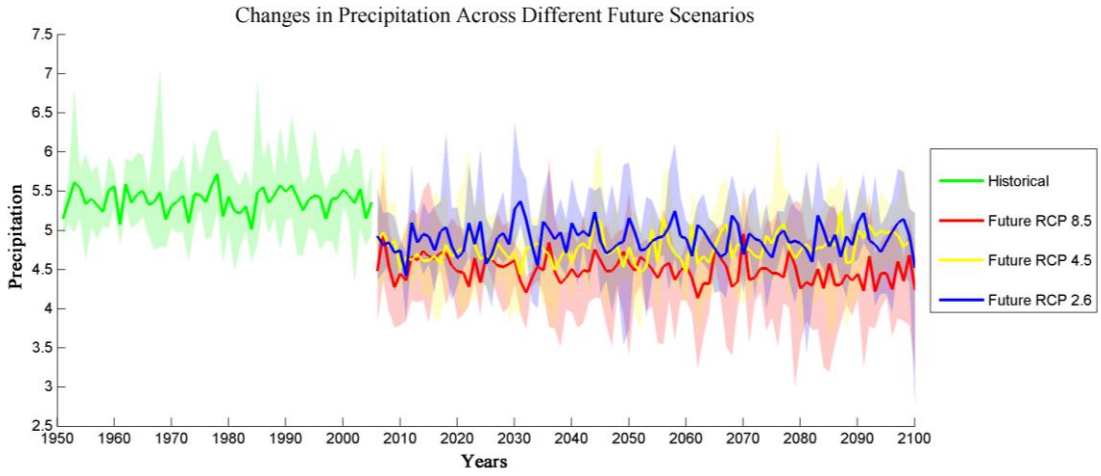


Figure 3.18: Simulated (1961-2010) and Projected (till 2100) changes annual precipitation intensity (mm/day)

Table 3.5: Annual changes in projected maximum temperature, minimum temperature and precipitation for the period 2021-30 w.r.t base line (1961-1990)

District	Simulated observed Average Tmax (°C)	Change in average annual Tmax w.r.t base line (oC)	Simulated observed Average Tmin (°C)	Change in average annual Tmin w.r.t base line (°C)	Simulated observed Average annual Rainfall intensity (mm)	Change in rainfall intensity (%)
	1961-90	2021-30	1961-90	2021-30	1961-90	2021-30
RCP 2.6	30.49	1.00	19.66	1.17	5.3	-8.98

District	Simulated observed Average Tmax (°C)	Change in average annual Tmax w.r.t base line (oC)	Simulated observed Average Tmin (°C)	Change in average annual Tmin w.r.t base line (°C)	Simulated observed Average annual Rainfall intensity (mm)	Change in rainfall intensity (%)
	1961-90	2021-30	1961-90	2021-30	1961-90	2021-30
RCP 4.5	30.49	1.04	19.66	1.22	5.3	-10.91
RCP 8.4	30.49	2.33	19.66	2.65	5.3	-22.25

Further, district wise average temperature (T, T_{max},, T_{min}) and seasonal precipitation have also been projected for all RCPs for the periods (2030s, 2060s and 2080s).The district level climate projections are important to capture the spatial variability, decipher resulting impacts across sectors and design appropriate location specific adaptation strategies. Exact district wise numbers of the projections are provided in Annexure 1.

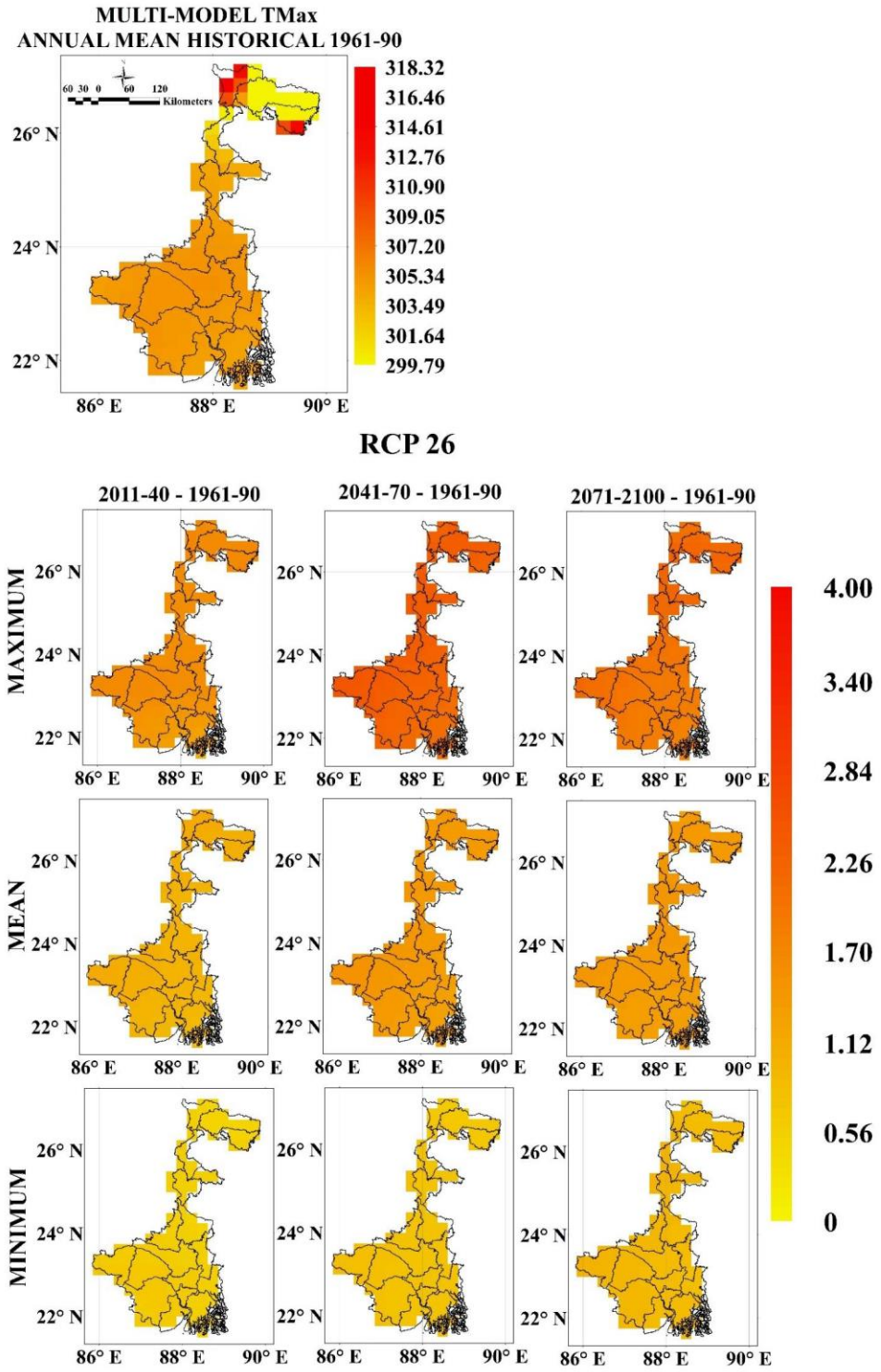


Figure 3.19: District level simulated (1961-1990) mean and projected annual maximum temperatures for the periods 2011-2040, 2041-2070, 2071-2100

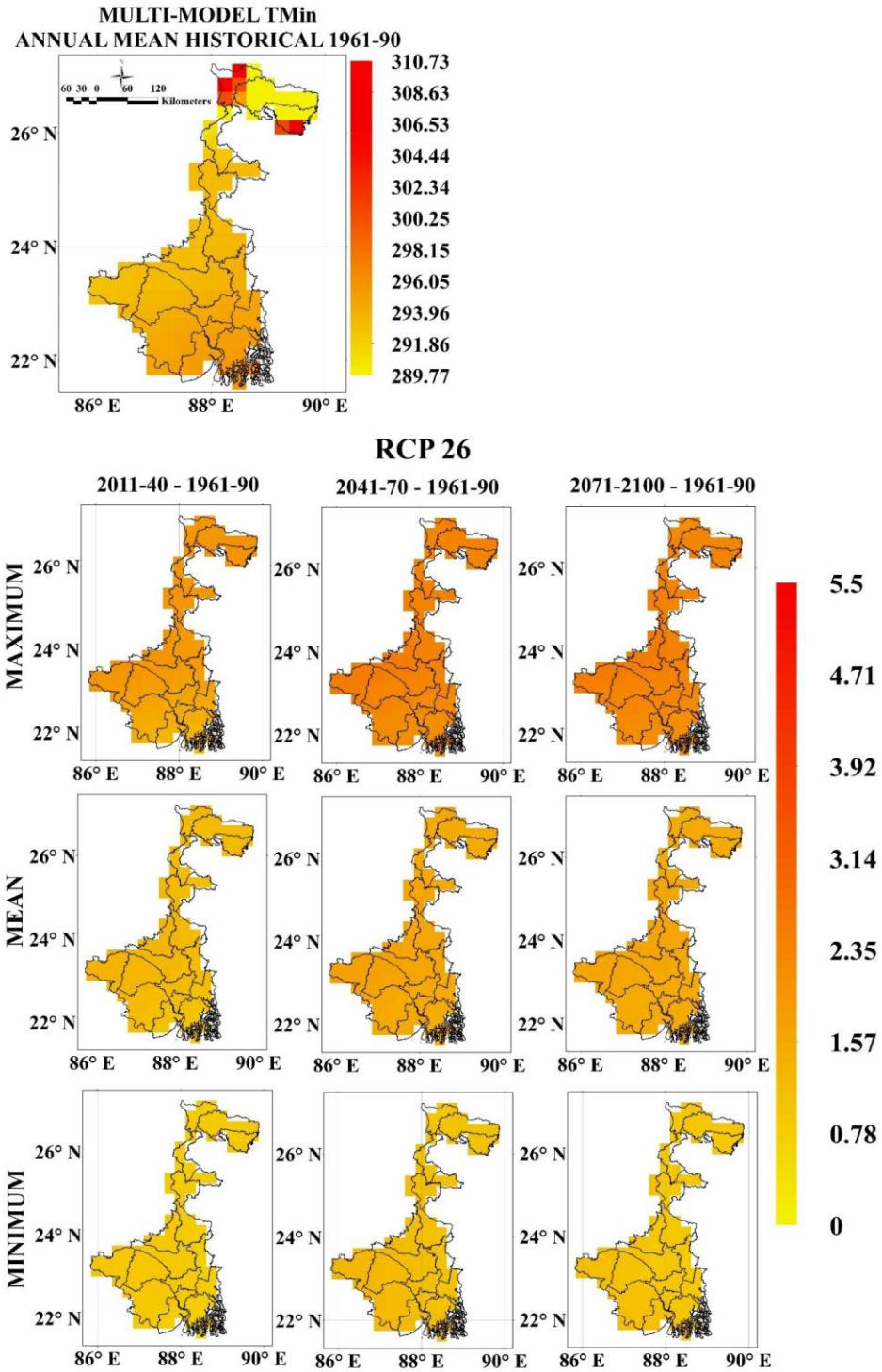


Figure 3.20: district level simulated (1961-1990) mean minimum temperature projections for the period 2011-2040, 2041-2070, and 2071-2100

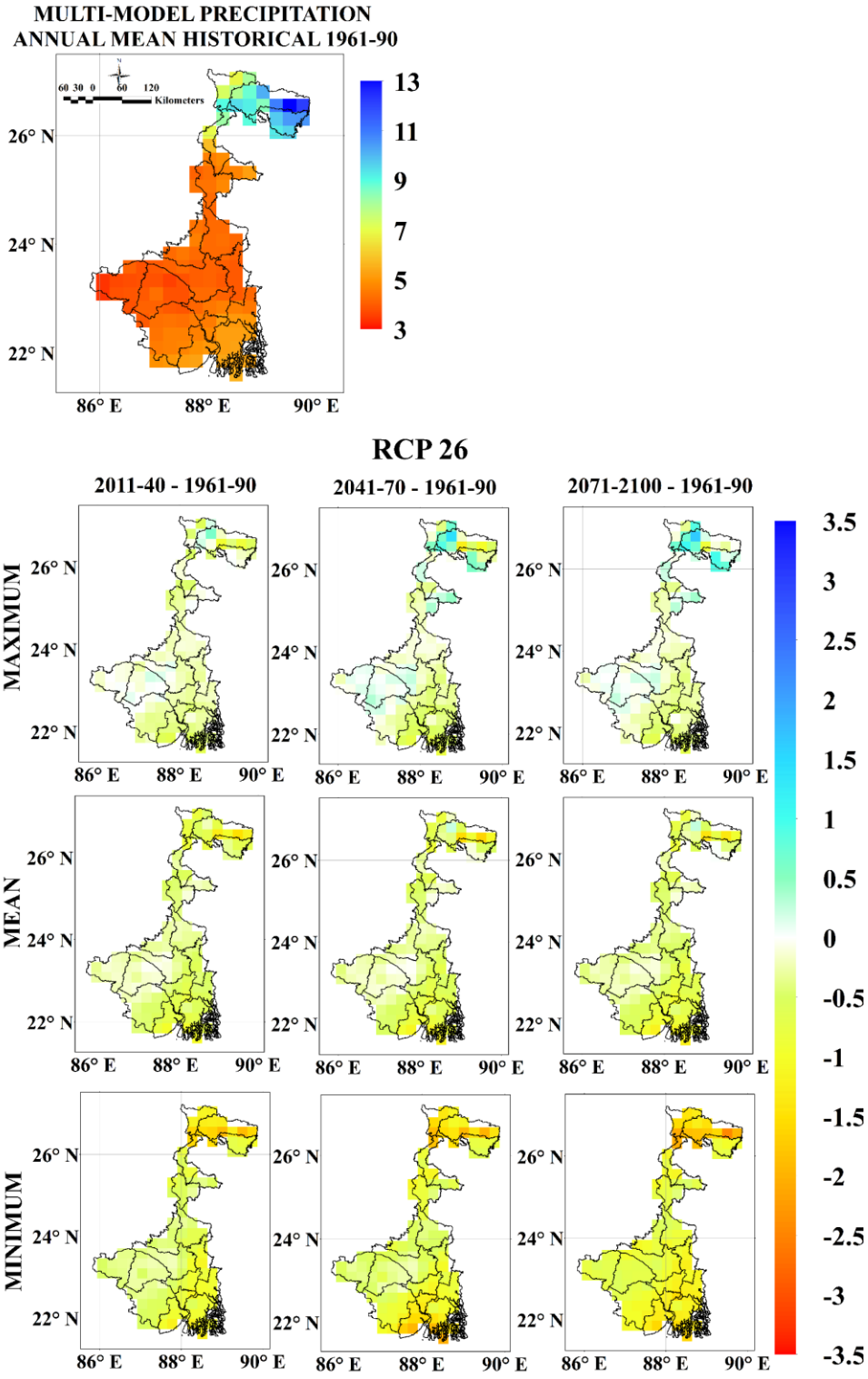


Figure 3.21: District wise mean annual precipitation and change in 2011-2040, 2041-2070, and 2071-2100

For three RCP scenarios (RCP 2.6, RCP 4.5 and RCP 8.5) the mean rainfall is likely to decrease by 0.5mm/day to 0.75mm/day but the maximum rainfall may increase by 0.25 mm/day for Darjiling-Jalpaiguri and northern parts of Bankura.

For three RCP scenarios (RCP 2.6, RCP 4.5 and RCP 8.5), summer months i.e. March, April and May shall receive less rain. Whereas the rain fall is projected to either decrease or remain same for all the districts for first three months of monsoon i.e. June, July and August but in September-October- November rainfall may increase Bankura, East Midnapur and West Burdwan by 1.2 m/day leaving other districts in dries state. However, the maximum rainfall may increase by 1.2 mm/day for large part of central West Bengal for same period. Winter months i.e. December, October and November shall receive less rainfall during 2021-30 with respect to base line i.e 1960-90.

District wise changes in fifty year return periods are shown in Maximum Temperature, Minimum Temperature and Precipitation are shown in Figures 3.23, 3.24, 3.25.

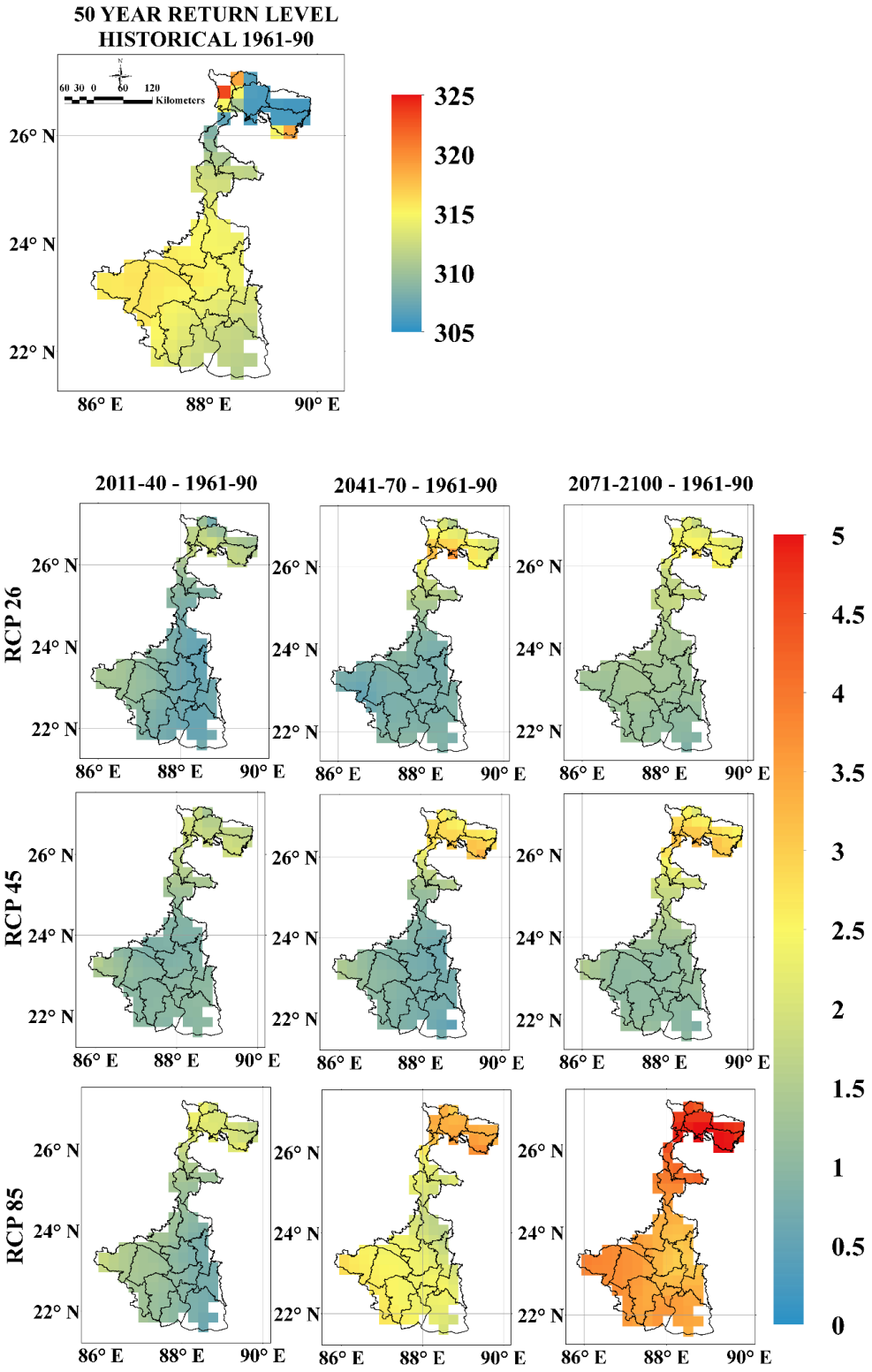


Figure 3.23: Changes in Fifty Year Return Period for Tmax (Maximum Temperature)

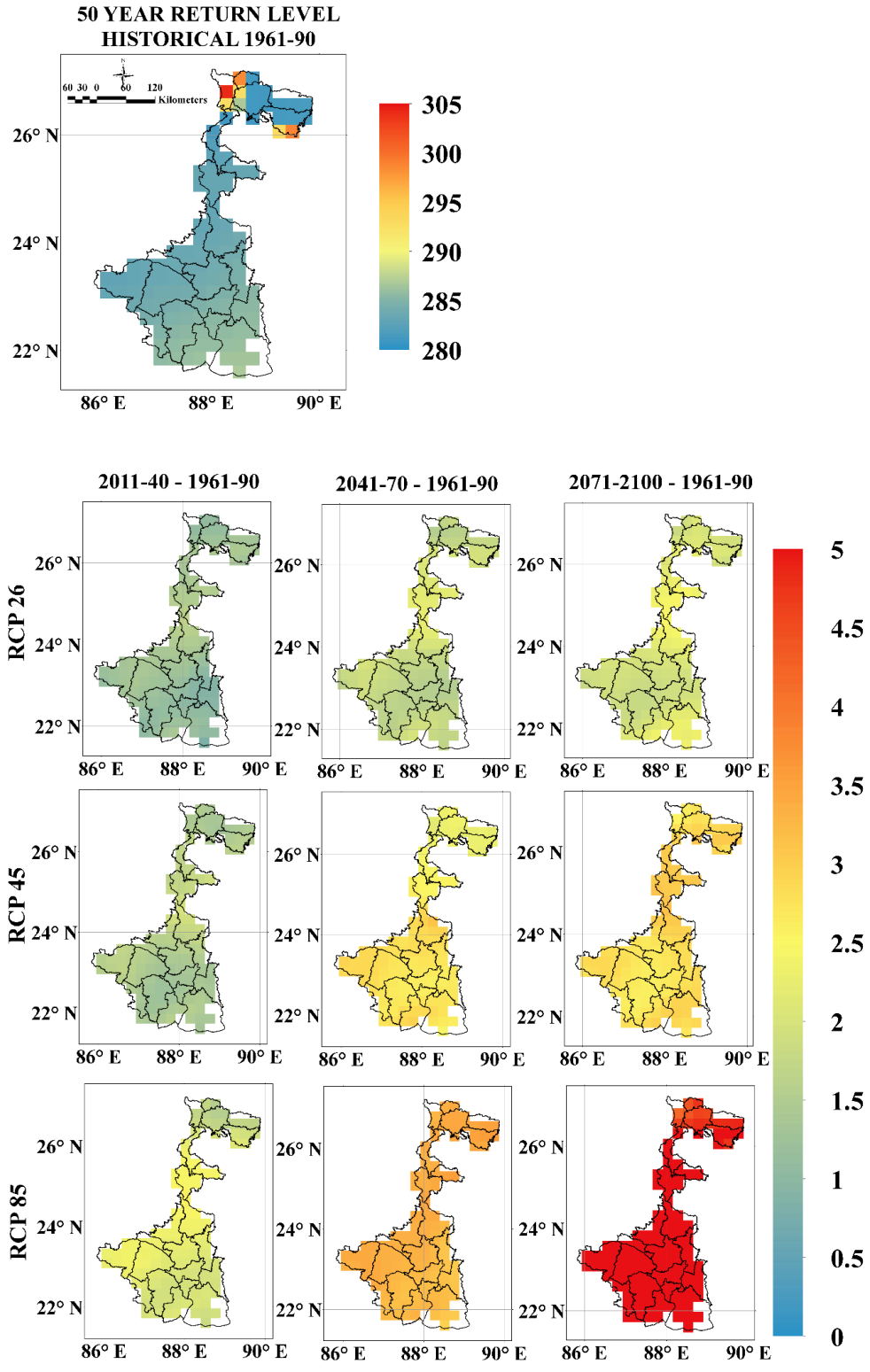


Figure 3.24: Changes in Fifty Year Return Period for Tmin (Minimum Temperature)

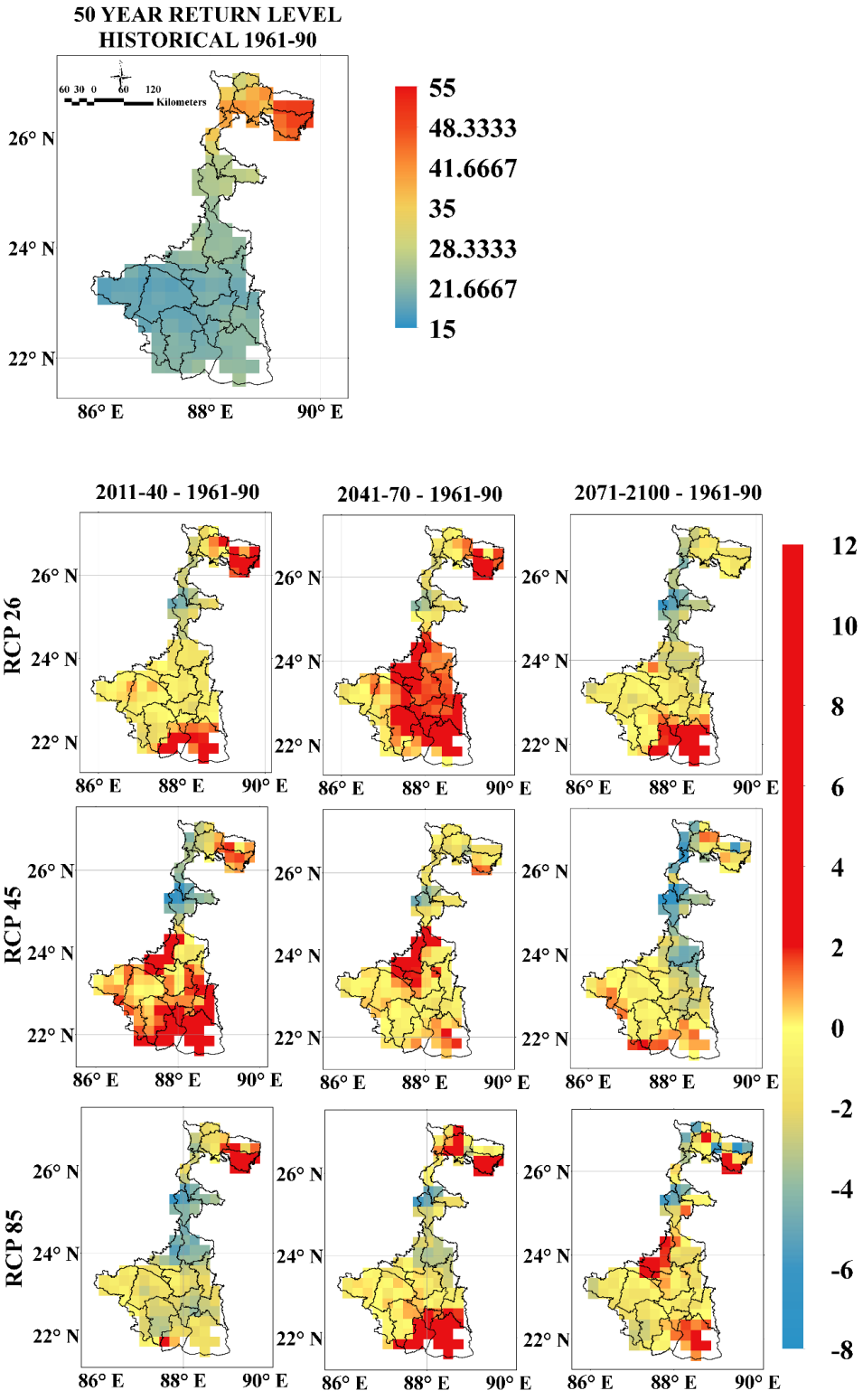


Figure 3.25: Changes in Fifty Year Return Period for Precipitation

ADAPTATION

4.0 Water

4.1 Sector Profile

West Bengal is perceived to be endowed with sufficient water reserves. Intensive abstraction and climate change poses questions to this age-old impression. The reason behind this perception originates from the mighty presence of the River Ganges. River Ganges enters the state near Farakka and divides the state into Southern and Northern parts. The Southern Bengal, which is part of lower Gangetic plain, is criss-crossed with river Hooghly and its tributaries. Rivers of North Bengal mostly originate from the snow-fed rivers from the Himalayas. On an average, the precipitation within the geographical territory of West Bengal generates 159.27 Km^3 of water annually. The surface water amounts to 77.06 bcm minus infiltration and evaporation. The replenishable groundwater resources amount to 31.72 bcm per year. The State receives 77% of the rain during the monsoon (June, July, August and September).

A small part of the infiltrated water eventually resurfaces as natural discharge and this amount may be regarded as an overlap between the surface water and the groundwater resources. After adjusting for this overlap, the total internal water resources of West Bengal comes to 105.82 bcm per year. The state also receives transboundary flow of water making the total annual water resources to 694.30 bcm (WBSoE, 2016[29]). This water is primarily drained out through a dendritic river system into the ocean by 39 sub basins of the three major rivers, namely, the Ganga, Brahmaputra and Subarnarekha.

Agriculture is major consumer of water followed by industries, forestry and energy generations (Figure 4.1). Agriculture is primarily rain fed. Although development of irrigation systems and drainage canals started in British era and is still being continued by the Irrigation and Waterways department and the Minor Irrigation department, the state is yet to be uniformly covered by irrigation canals.

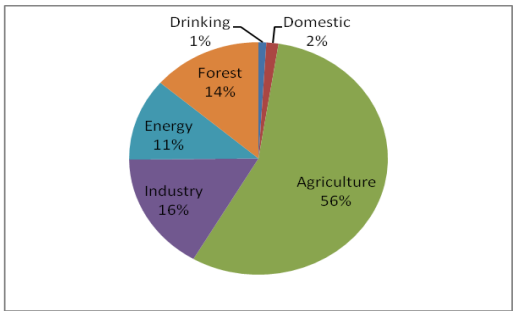


Figure 4.1: Percentage of water demand in different sectors in West Bengal[30]

[29] WBSoE, 2016. West Bengal State of Environment Report, 2016, Government of West Bengal

[30] WBSoE, 2016. West Bengal State of Environment Report, 2016. Published by the Environment Department. Government of West Bengal, Table 8.8, page 148

Minor irrigation plays a key role as major and medium irrigation schemes cover only 2.44% of total irrigated area. The Minor irrigation schemes are mostly based on groundwater. As mentioned above ground water accounts for about 30 % of total internal water resources. At present state utilizes about 42% of the assessed annual renewable ground water resource, estimated at 27.4 bcm[31]. Out of total 341 blocks in state of West Bengal[32], the quality of groundwater is a serious concern in 140 blocks because of presences of:

- High concentration of arsenic in 81 blocks of Maldah, Murshidabad, Nadia, North 24 Parganas, South 24 Parganas, Haora, Hooghly and Burdwan
- High Salinity in 59 blocks in North 24 Parganas, South 24 Parganas, Purba Medinipur and Haora districts
- High concentration of Fluoride in 3 blocks of Bankura and Birbhum

A total of 111 Blocks are flood prone, which cover 37,660 sq km i.e. 42% of geographical area of the state[33].

4.2 Major Impacts Envisaged in SAPCC 2012 for Water Sector

- Reduction in available water resources
- Increased probability of floods and water logging due to increase in extreme rainfall events

4.3 Summary of Adaptation Strategies Proposed in SAPCC 2012

The SAPCC 2012 has an elaborate list of proposed actions to improve the conditions of water resources and also to improve flood management. These actions can be categorized as:

1. Surface water resources conservation and improvement
2. Ground water resources conservation and improvement
3. Flood management
4. Erosion Control
5. Drinking water supply

Improvement of water resources are done by watershed/springshed management, water harvesting, construction of check dams, rejuvenation/creation of water bodies and introduction of monitoring network.

[31] State Agriculture Plan (XIIth FYP- 2012-2017) and draft vision plan –page 40
[32] Statistical Abstract 2015
[33] Annual Flood Report 2016, Irrigation and Waterways Department, Government of West Bengal (http://www.wbiwd.gov.in/uploads/ANNUAL_FLOOD_REPORT_2016.pdf) and draft vision plan – page 40

Irrigation and Waterways, Minor Irrigation, Urban and Municipal Engineering Department, Public Health Engineering Department, Water Resources and Water Investigation Department, Panchayats and Rural Development Department also play key role in the management and supply of water.

4.4 Key Achievements in Context of Climate Change Adaptation during 2012-2017

4.4.1 Water resource conservation and improvement till 2016

- 2,27,101 water bodies/water detention structures have been created34. Out of which, 1,963 lakh cu m of water storage was achieved by creating tanks of 40x30x3 cu m size in red laterite zones, i.e by creation of 54,527 nos of tanks35.
- Developed springsheds covering an area of 600 ha developed in Hill Region of Darjiling.
- Created 0.14 million hectares of irrigation potential36
- Created 0.20 million hectares of irrigation potential by construction of 209 check dams.
- Introduced 101 ground water recharge systems
- A huge groundwater monitoring net work has been taken with 20,000 monitoring wells and 60 real time groundwater monitoring wells
- Rejuvenated 76 km of canals. More than 1.12 million hectares of additional area brought under irrigation coverage.

4.4.2 Flood Management till 2016

- Resurrected 1,589 km of drainage channels
- Revamped 402 km of canal network.
- Works on flood management covering 1.88 lakh hectare (1,880 sq kilometer) in the traditionally flood prone areas37
- Strengthening and improvement of 3,121 km embankments in Sundarbans area, which is one of the most vulnerable area in context of climate change.

4.4.3 Water Supply

- *Water supply in general* - The state is striving to expand the water supply network as good quality water is building block of improving community health. The Urban and Municipal Affairs Department (U&MA) has commissioned 55 projects for 55 urban local bodies under the Water

[34] Economic Review 2017-18, Government of West Bengal by Department of Planning, Statistics and Programme Monitoring, GoWB, page 361 section 15.14
[35] Economic Review 2016-17, Government of West Bengal by Department of Planning, Statistics and Programme Monitoring, GoWB, page
[36] Economic Review 2017-18, Government of West Bengal by Department of Planning, Statistics and Programme Monitoring, GoWB, page 356, Table 15.1
[37] Economic Review 2017-18, Government of West Bengal by Department of Planning, Statistics and Programme Monitoring, GoWB, page 357

Supply Scheme, with population coverage of 6,118,884 citizens. 55.5% of state's population use safe drinking water services[38].

- *An innovative step in water supply* - A mass scale decentralized roof top based rain water harvesting supply scheme for poorer section of Darjiling – hill town has been taken up in 2016. This project has been facilitated by the Department of Environment and has been funded by National Adaptation fund under Climate Change. (NAFCC) On completion in 2019, the project is expected become an example for promoting mass scale decentralized water supply by rain water harvesting. Municipal Engineering Directorate is the executing agency of the project.

4.5 Impacts envisaged in 2017 for period up to 2030

District wise statistical downscaling of Global Circulation Model (GCM) has been done by IIT Bombay. The observations made in this study along with scientific input obtained from IITM, Pune and other publications have been summarized in section 3.2. The total water available from precipitation is projected to decrease by 8 to 22%. The rate of evapotransmission shall increase due to temperature rise. This can seriously reduce the volume of available total internal water resource, which is estimated to be 105.82 bcm per year[39] at present. Reduction of available water from declining precipitation and enhanced evaoptranspiration can alter the dynamic equilibrium of hydrological cycle. Alteration in hydrological forcings shall also change the ecological balances. Rain fed agriculture may get lesser water. This will be discussed in agriculture section in detail. Adhikari and Iving (2016) pointed out to significant changes in earth obliquity due to changes TWS (Total Water Storage) in India[40]. As the dry periods are expected to be drier and wet period is expected to be wetter, chances of flood and water logging are also estimated to rise. Problems of flooding may be compounded by the sudden spike in transboundary flow of water due to excess runoff in upstream basins. In other words, the state may loose its advantage of having sufficient water resources and simultaneously may faces floods and inundations.

4.6 Ideal Strategies for Water Sector

Water conservation and management practices has to be flexible enough to cope up with climate stress generated from draught and flood within same season and same year As a part of long term action plan the water conservation and development of water resources have to be further strengthened. Watershed and river basin management programmes are to be expanded and implemented in time bound manner. A strong and regular monitoring of ground water level at various locations within the state as well as of flow in a river or tributary shall provide information about the water availability and help to draw the response action plan. Monitoring of water levels in rivers and early forecasting of

[38] PHED, GoWB and Draft Vision Plan page -72

[39] WBSoE, 2016. West Bengal State of Environment Report, 2016, Published by the Environment Department. Government of West Bengal

[40] Adhikari and Iving, Climate Driven Polar Motions, *Science Advances* 08 Apr 2016, Vol. 2, no. 4, e1501693 DOI: 10.1126/sciadv.1501693, http://advances.sciencemag.org/content/2/4/e1501693

impending rain within the state and in upstream basins can be used for flood control and disaster management programmes.

4.7 Actions and Targets adopted by the Departments

4.7.1 Water Conservation and Flood management

- Water Shed Management (540 springsheds and 600 watersheds by 2018) and Rain Water Harvesting
- Increase reservoir storage potential of major irrigation projects by way of removal of siltation, addressing leakage issues and lining of sides of cannel system to minimize percolation
- National Hydrology programme is being implemented by Irrigation Department. The programme involves real time flood forecasting. This will take care of majority of the actions for flood control, which is a major threat in the context of climate change. Mathematical modelling to map the flood protection work needed in each block is being done to develop a web based comprehensive flood forecasting/ warning system for flood prone areas and bringing 30% of the total flood prone area under the system by 2020
- Reduce the gap between IPC (Irrigation Potential Created) and IPU (Irrigation Potential Utilized) and bring more area under surface irrigation by harnessing rainwater and tidal water by covering additional 13,300 ha by 2020 and continue the work up to 2030
- Improvement of 1,280 km of embankment by 2020 and improvement of 650 km of drainage channel and also construction of new drainage channels in flood prone areas[41]
- Implementation of coastal protection plan
- Augmenting drainage systems & facilities by renovating/ remodeling of embankments along existing river systems (Mayurakshi-Bhagirathi and Kangsabati)

4.7.2 Water Supply

- Bringing additional 1,25,24,477 people under coverage of piped water supply by completion of ongoing 35 water supply projects in 35 urban local bodies (ULBs) having population coverage of 1,18,69,159 people and undertaking 12 projects, which are in the pipeline having a population coverage of 6,55,318 people[42].
- Successful completion of the mass scale water supply by decentralized roof top rain water harvesting in about 3,200 poorer households can pave a new avenue for water supply in other isolated hill towns.

4.8 Other Possible Targets and Actions

Ensuring 1,700 m^3 per capita water availability for every year: The per capita water availability in West Bengal was 4,023m^3 in 1951 and in 2011, it has declined to be 1,159m^3 per person[43]. Availability of 1,700

[41] Draft vision plan – page 135
[42] Draft vision plan – page 72
[43] SOE 2016 Report page 147

m^3 of water per capita per year is expected to meet all the demands of human being[44]. Considering a decadal growth rate of 13.8% in population, annually 175 bcm water needs to be made accessible for this purpose.

A framework of water conservation – monitoring of water reserve – feed back and follow up mechanism is to be constituted to strive towards this target. Use of GRACE and other earth observations can be used for this purpose.

Instituting preparedness for flood control and water logging: Climate Change is increasing the uncertainty in occurrence and degree of intensities in flood. An early forecasting and immediate response mechanism can help minimizing the environmental and social damages.

Bringing water use efficiency and accessibility in to focus: Water scarcity is increasing due to various non climate-factors. Climate change is aggravating the water crisis. Improving water use efficiency can reduce the water demand. Efficient use of water in agriculture, industry and energy generation is possible by use of newer technologies and behavioral changes.

Awareness generation and community participation**:** Consensus building to the level of end users and active participation of the citizens can improve water conservation programmes to a considerable extent.

Alignment with NDC, India and UNSDGs

The State Action Plan on Climate Change 2017 is also aligned with the NDC, India as the NDC, India includes:

- Water conservation under NWM (National Water Mission), minimizing waste and ensuring equitable distribution both across and within States through integrated water resources development and management.
- Making available a comprehensive water data base in public domain and assessment of the impact of climate change on water resource
- Promotion of Citizen and State Action for water conservation, augmentation and preservation
- Focused attention to vulnerable areas including over-exploited areas. Flood prone areas, saline areas etc.
- Improving water use efficiency by 20% across all sectors
- Promotion of basin level integrated water resources management and National Mission for Clean Ganga.

[44] SOE 2016 Report page 147; Falkenmark, Malin and Johan Rockstorm (2005): Balancing Water for Humans and Nature/ A new approach in Ecohydrology, Earthscan, London, p.xxi)

5.0 Agriculture

The Agriculture Sector also includes Fisheries, Annual Resource Development, Food and Horticulture under its ambit and each sector is described in brief in this section.

5.1 Agriculture

5.1.1 Sector Profile

Agriculture is the backbone of West Bengal. Nearly 39% of the total workforce[45] are engaged in agriculture and allied services[46] and contributed 12% to the Gross State Domestic Product at constant prices (2004-05) in the year 2014-15[47].The total cultivable land in the West Bengal is 5.6 million hectares which is about 65.25 per cent of total geographical area of the State[48]. The sector employees are 65% of the rural population. The State of West Bengal is divided into 6 agro-climatic zones, viz, Hill Zone, Terai Zone, Old Alluvial Zone, New Alluvial Zone, Red Lateritic Zone and Coastal Saline Zone on the basis of climatic factors, soil structure, texture, type, topography *vis-à-vis* ground water availability etc. Of these, Hill Zone, Terai Zone, Red Lateritic Zone and Coastal Saline Zone are identified as stressed zones[49].West Bengal is leading in production of rice, potato, vegetables, fish, meat and is a significant producer of pineapple, litchi, mango mandarin orange and flower. West Bengal supplies nearly 33% of the potato requirements and 66% of the jute requirements of India[50]. Different food products grow in different agri meteorological zones and are impacted by different degrees of change isn the weather parameter. The agriculture sector in West Bengal is characterized by the predominance of small and marginal farmers (95.4%) who own 84% of the land. The per capita share of land is only 0.07 ha. (State of Environment Report West Bengal, 2016).

West Bengal has one of the highest cropping intensities in India (185%) as the state is seriously constrained in terms of land availability. High cropping intensities put tremendous pressure on it's soil and water resources. However, other advantages such as good rainfall, fertile alluvial belts, and generous surface and ground water resources in conjunction with good irrigation infrastructure has enabled the State to play a crucial role in meeting the food security of the country. It is today a leading producer of producers of rice (160.70 LMT) with yield of 2.9 Mt/ha, food grains (180.35 Mt)[51] potato (90 LMT), vegetables (140 LMT), jute (15.8 LMT) (NABARD). It is also a significant producer of pineapple, litchi, flowers, mango and mandarin orange (Economic Review 2016-17).

[45] State of Environment Report West Bengal, 2016
[46] Census 2011 and Draft Vision Pan page 33
[47] Statistical Abstract , 2015
[48] (State of Environment Report West Bengal, 2016)
[49] (State of Environment Report West Bengal, 2016)
[50] Economic Review 17-18 page 23
[51] Economic Review 17-18

5.1.2 Major Impacts Envisaged in SAPCC 2012 for Agriculture

Major impacts as envisaged in SAPCC 2012 are summarized in Table 5.1.

Table 5.1: Agro-climatic Zone wise Summary Impacts of Potential Climate Change

Sl. No.	Agro-climatic zone	Area (ha)	Districts	Main Crops	Potential Climate Change Impacts
1	Hill Zone	2,42,779 (2.79%)	Darjiling (except Siliguri subdivision) and Northern part of Jalpaiguri	Maize, rice, different vegetables, potato, soybean, cardamom, ginger, medicinal plants, tea, orange etc.	• 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 Darjiling tea due to increase in extended drought periods. • Increase in winter temperature effecting potato and wheat. • Degradation of seed quality.
2	Terai Zone	12,14,880 (13.99%)	Darjiling (only Siliguri subdivision), Jalpaiguri, Alipurduar, Koch Bihar, Uttar Dinajpur (only Islampur subdivision)	Rice, jute, tea, pineapple, potato, pulses, oilseeds etc.	• 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.**
3	Old Alluvial Zone	17,53,757 (20.20)	Dakshin Dinajpur and Part of Murshidabad, Bankura, Haora, Hugli, Burdwan, Birbhum, Paschim Medinipur and	Rice, wheat, maize, jute, mustard, niger, groundnut, sesame, linseed, lentil, blackgram, greengram, pigeonpea, vegetables etc	• 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 would be at stake due to water stress in future • Wheat productivity has decreased due to

Sl. No.	Agro-climatic zone	Area (ha)	Districts	Main Crops	Potential Climate Change Impacts
			Purba Medinipur		shorter winters • Temperatures in excess of 45-46 ^{0}C in summers is impacting productivity of oilseeds and pulses • Also excess temperatures is affecting livestock productivity • Increase in pests and disease due to increase in foggy days affecting pulses
4	New Alluvial Zone	15,30,415 (17.62)	Nadia, Murshidabad, Maldah, Uttar Dinajpur, Barddhaman, Hugli, North 24 Parganas and Haora	Rice, wheat, maize, jute, greengram, blackgram, pigeonpea, lentil, rapeseed, mustard, groundnut, sesame, linseed, niger, vegetables etc.	• 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 24-38^{0}C, any increase in temperature may affect 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 due to increasing winter temperature.
5	Red Lateritic Zone	24,84,244 (28.61)	Entire Puruliya and part of Barddhaman, Birbhum, Bankura, Purba Medinipur and Paschim Medinipur	Rice, maize, millets, vegetables, niger,toria, safflower, mustard, sesame, pulses, potato, vetiver, sabai etc	• Rainfall is inherently scanty in this zone as compared to other agro climatic zones in West Bengal and is reducing further. • Also temperatures, both maximum and minimum, are rising. • Agriculture mainly rain fed, only 27% of the land area is irrigated. • Soil is poor in nutrient content and likely to become drier. • Degradation of quality seeds.

Sl. No.	Agro-climatic zone	Area (ha)	Districts	Main Crops	Potential Climate Change Impacts
6	Coastal Saline Zone	14,56,879 (16.77)	Entire South 24 Parganas and part of North 24 Parganas, Haora and Purba Medinipur	Rice, chilli, vegetables, sunflower, sesame, watermelon, *Lathyrus* etc	• 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 up to 40 km from Kolkata. • Natural salinity of the soil is increasing due to recurrent intrusion of sea water; resulting in loss of agricultural land and making people migrate. • Longer span of summer increased insect and pest attacks on crops. • The delayed winter has hampered the cultivation of winter crops. • The intrusion of saline water causes severe stress on availability of drinking water. • Increasing humidity leads to incremental phenomenon of vector borne diseases. • Degradation of quality seeds.

Sources:

1. Principles of Agronomy. S R Reddy (2010). Kalyani publishers. Ludhiana.

2. NARP status reports for different Agro-climatic Zones (1991). Bidhan Chandra Krishi Viswavidyalaya.

3. Sahaj kathay bijnanbhittik chashbas. Gosthto Nayban (2008). Ananda Agency, Kolkata.

4. State of Environment Report, West Bengal, 2016, West Bengal Pollution Control Board

5.1.3 Summary of Adaptation Strategies Proposed in SAPCC 2012

The agricultural sector in West Bengal is highly vulnerable to climate change given its geographical exposure especially it's coastline, Himalayan areas and its drier districts as well as it's socio-economy sensitivity due to a high level of dependence on it as a source of livelihood. Region wise descriptions of the potential climatic changes impacts on the sector are given the Table 5.1 above. Having gauged these impacts, the SAPCC 2012 provided an elaborate list of adaptation strategies. The Agriculture Department has implemented many of these strategies and the Economic Review 2016-17 suggests that following measurse were emphasized:

- Diversified Cropping programme[52,53]

[52] Economic Review 2016-17, page 52

- Farm Mechanaisation[54,55]
- Consewrvation of Soil Moisture[56]
- Enhanced Water Harvesting[57]
- Extensive training and Capacity Building
- Use of ICT

Economic Review 2016-17 also proposed to include[58]:

- Use of location specific technology for increasing productivity
- Bringing in fallow lands under cultivation
- Promotion of conservation agriculture approaches such as zero tillage
- Bringing more areas under irrigation to facilitate enhancement of cropping intensity
- Promoting use of integrated farming approaches
- Integrated nutrient and pest management
- Use of water saving methods as System of Rice Intensification (SRI) and other forms of systems of crop intensification

5.1.4 Key achievements of Agriculture in Context of climate change

- Temporal analysis for food grain suggests that production and yield has increased for food grains in 2012-17 in spite of delayed monsoon, less rainfall and rising maximum temperature (Figure 5.1).
- Year wise analysis of different products for 2015 also suggest that in spite of deficient rain (4% departure in Sub-Himalayan and Gangetic West Bengal in 2015 and 2% departure in Sub-Himalayan and 6% departure in Gangetic West Bengal[59]) the production soared[60] for :
- Pulse by 33.82%
- Oil seeds by 28.11 %
- Food grains by 19.79%
- Creation of 1,635 rain water harvesting structure, 38 check dams, 18 percolation tanks, 605 of other harvesting structures in 2015-16[61]
- Renovation of 2,149 old rain water harvesting structure[62]

[53] Economic Review 2017-18, page 35
[54] Economic Review 2016-17, page 48
[55] Economic Review 2017-18, page 33
[56] Economic Review 2016-17, page 42
[57] Economic Review 2016-17, page 43
[58] Economic Review 2016-2017 page 37
[59] Economic Review 2016-2017 page 39
[60] Economic Review 2016-2017 pages 38-39
[61] Economic Review 2016-2017 page 51
[62] Economic Review 2016-2017 page 51

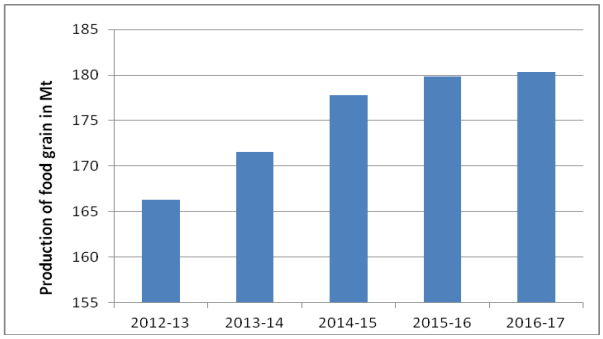


Figure 5.1: Production of food grain during 2012 to 2017 in lakh Metric ton (LMT)[63]
Note 10 lakh=1 million

Establishment of linkages among each measure and productiivity is beyond the scope of this SAPCC, 2017. However adaptation measures worked well in circumventing the productivity. As for example, strong co-relation (R^2=0.85) can be found between farm mechanisation in terms of kWH/ha and productivity in terms of food grains in kg/ha (yield per unit area), which is shown in Figure 5.2. Small land holdings of the state is a deterrent for cost and energy intensive farm mechanization. This disadvantage is being overcome by the active role of PACAS (Primary Agriculture Cooperative Society). by setting up about 2,000 farm machinery hiring centres have in the state. Tractors, Power Tillers, Pump Set, Power Reapers, Paddy Tran planters, Power Thrashers etc are being made available to small and medium farmers.

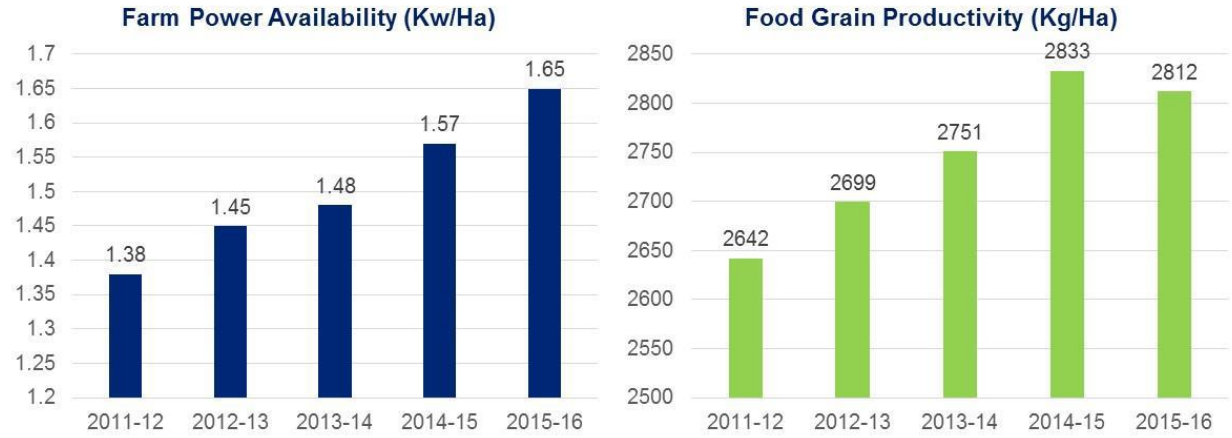


Figure 5.2: Farm Mechanisation (kWH/ha) and Productivity (kg/ha)

5.1.5 Impacts envisaged in 2017

In section 3.2 of this report, maximum and minimum temperatures are projected to rise at different rates, which means the climate shall become warmer and diurnal differences shall reduce. The evapotranspiration rate shall also increase in warmer weather. These changes may impact the plant

[63] Draft Vision Plan 2016-17, page 33-34

physiology and productivity. The rainfed agri-culture is expected to receive less water from precipitation. Rain is likely to reduce in the summer months and in the winter months making crop rotation a difficult task. There can be drought and longer duration of heavy rains resulting in to prolong water logging in the same season. Selection of crop for sowing become a complex decision making process. Bhattacharyya and Panda[64] shows that the grain yield increased an average of 0.35 kg/ha with per mm increase in rainfall and decreased by 156.2 kg/ha per degree rise in mean temperature at that region. Considering 10.99 million ha[65] area for all types of rice production, there can be 5% reduction in the production of rice for every 1 degree rise in temperature. Reduction of rainfall and other feed back mechanisms can reduce rice productivity even at a higher rate. However, recent researches also show that rising temperatures narrow the transmission window for many pests and thus warming may save the crops from pest attacks and also reduce the indiscriminate use of pesticides.

Working in a hot and dry weather increases morbidity and prolong exposure in very hot weather can cause heat stress in farmers, who are working in the field. Heat waves cause livelihood problems in this sector.

5.1.6 Ideal Strategies for Agriculture Sector

SAPCC 2012 included a list of proposed actions including those discussed above:

- **Crop diversification**
- Introduction of climate smart crop varieties
- Encouraging indigenous cultivars
- Upscale Resource Conservation Technologies (RCTs)
- **Water harvesting through ground water recharge**
- Introduction of drip irrigation in Red and Laterite zone
- Introducing aerobic rice, direct seeded rice, and SRI technologies
- **Introduce farm mechanization for planting technologies**
- Encouraging brown manuring
- **Introducing sequential cropping**
- **Nitrogen management through LCC (Leaf Coloured Chart)**
- **Popularize the concept of Integrated Farming System (IFS)**
- **Undertake effective soil nutrient management**
- **Develop biological ways for combating weeds, insect, pests and diseases and nutrient management**
- **Strengthen research and development**
- **Effective outreach for advisory to farmers on various aspects of agriculture**

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[64] Effect of climate change on rice yield at Kharagpur, West Bengal Tanmoyee Bhattacharya, Dr. R.K Panda, *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 4, Issue 2 (Jul. - Aug. 2013), PP 06-12 www.iosrjournals.org*

[65] Economic Review 2017-18,Department of Planning, Statistics and Programme Monitoring, Government of West Bengal , page 25

- **Develop seed storage facilities**
- **Access to funds for farmers to enable them to develop market ready products**
- Expand the coverage of crop insurance to small and marginal farmers
- Enhance access to markets by building infrastructure
- Encourage public-private partnership for easier penetration of all strategies

5.1.7 Actions and Targets Adopted by the Departments

The lists of activities, which are provided in bold letters in the previous section, are being prioritized by the state agriculture department to achieve productivity of rice by 43% and pulses by 214%. Targets are also being set to increase productivity. As for example productivity for vegetable crops as a whole may be increased on an average 20 t/ha through adoption of modern production technologies[66]. Integrated Pest Control Scheme is being taken up in the Agricultural Department to respond to threats of pests due to change in climate. This will be incorporated in future State Action Plan of climate change.

5.1.8 Other Possible Actions

The other possible actions may include the remaining actions, which are not in Bold in the list above. Considering the uncertainties, which is being induced by climate change, the response mechanisms have to be fast and flexible. Use of climate change services rendered by different scientific organizations like extended weather forecasting and issuance other advisories can help this sector to take effective measures in time.

Benefits of small holdings can be reaped off through re-cropping programme in case of longer duration of rain. However, good quality seeds should be available for re-cropping. Enhancement of storage capacities are another area, which need immediate attention. Reaping the crop just before an intensive rain needs to be stored properly.

5.2 Animal Resource Development (ARD)

5.2.1 Sector Profile

West Bengal is rich with diversified animal resources. These include livestock (Cattle, Buffalo, Sheep, Goat, Pig, Horses & Ponies, Mules, Donkeys, Camels, Mithun and Yak) and poultry (total birds in the poultry farms and hatcheries). Some key species found in West Bengal include the Black Bengal Goat, Garole Sheep and Ghungru Pig. People in rural and semi-urban areas rear different types of animals.

[66] Draft Vision Plan - 122

Table 5.2: Animal Resource Distribution[67]

Animal Resource	Number
Cattle	1,65,14,239
Buffalo	5,97,379
Sheep	1,076,115
Goat	11,505,950
Pig	648,111
Horses & Ponies	4,408
Mules & Donkey	609
Camel	267
Mithun & Yak	1,089
Total Livestock	**30,348,280**

Fowl	22,826,205
Duck	6,257,476
Other Poultry	61,597
Poultry	**52,837,576**

These resources contribute to the food security and nutritional requirement of the state through the production of protein rich food like meat, milk, eggs etc. Further, they provide income generation and diversification opportunities in rural areas, particularly among the landless laborers, small and marginal farmers and women. In 2013-14, animal husbandry provided employment to 25.27[68] lakh people in the state. More and more people are taking up animal husbandry as a result of a gradual shrinkage of agricultural lands because of urbanization and due to limited scope of absorption of rural unemployed youth into the industrial and service sector.

Table 5.3: Livestock Production in 2015-16[69]

Livestock Product	Production ('000 MT)
Milk	5038
Egg	6011
Meat	685
Wool	748

[67] 19th Livestock Census-2012 All India Report, Department Of Animal Husbandry, Dairying And Fisheries, Ministry of Agriculture
[68] Annul Administration Report 2013-14, Animal Resources Development Department, Government of West Bengal
[69] Economic Review 2016-17,Department of Planning, Statistics and Programme Monitoring, Government of West Bengal

5.2.2 Major Impacts Envisaged in SAPCC 2012 for ARD

Animal resources are very susceptible to climate change. Climate changes like increasing temperatures and humidity can directly impact animals by increasing animal stress, lowering their productivity and impairing their reproductive functions. It can also have an indirect impact on animal resources by affecting feed and fodder availability. Allocation of land for fodder cultivation is difficult and cultivation of Azolla or production of green fodder by hydroponics technology may meet the growing demand for green fodder. Climate change also leads to the spread of diseases. Keeping this in mind, some of the strategies adopted in West Bengal are provided in section 5.2.3[70].

5.2.3 Summary of Adaptation Strategies Proposed in SAPCC 2012

- Promotion of small ruminant breeds
- Strengthening of disease investigation system
- Preventive health measures like regular vaccinations
- Improved cattle sheds for alleviating heat stress in livestock
- Feed and fodder development like Azolla cultivation or hydroponic green fodder production
- Dairy Development
- Risk Management through insurance coverage
- Capacity building of live stock farmers, self help groups and other support members for effective adaptation to climate change

5.2.4 Key Achievements of ARD in Context of Climate Change up to 2017

- Live stock product has increased by 14 %[71]
- Forty (40) number of mobile veterinary clinics (MVC) have been launched to provide animal care at door step inof remote blocks[72].

5.2.5 Impacts envisaged in 2017

Tables… in Annexure, suggest that the maximum temperature for 16 out of 23 districts (Murshidabad, Birbhum, Purba Bardhaman, Nadia, Haora, Hugli, Puruliya, Bankura, Paschim Medinipur, Purba Medinipur, 24 Parganas (South), 24 Parganas (North), Kolkata, Paschim Bardhaman, Jhargram) will exceed 32^0C (or 90^0 F). The body weight of chickens starts falling as this 90^0F thresh hold is crossed[73]. A previous study by ICAR showed that the mortality of heavy meat type chicken is significantly high (8.4%) when the temperature is above or equal to 34^0C[74].

Physiological responses such as respiratory frequencies, heart rate, and energy expenditure can be doubled or tripled for an increase of 1^0 C rise in temperature. Many species of livestock find it difficult to

[70] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal
[71] Table 2.17 of economic Review 2016-2017
[72] Economic Review 2016-17 page 86
[73] ICAR, "Management of Heat Stress in Poultry Production System" March 2016, Page 3
[74] http://www.icar.org.in/files/reports/icar-dare-annual reports/2010-11/ climate-change-AR-201-11.pdf

tolerate THI (Temperature Humidity Index) more than 80. Milk production also declines at a higher temperature. The transmission window of vector borne disease may expand and productivity can be seriously impacted. Quality of feed and fodder also deteriorates if temperature increases.

5.2.6 Ideal Strategies for ARD Sector

5.2.6.1 Actions and Targets adopted by the Departments[75]

Table 5.4: Expected Increase in Livestock Production

Livestock	2020	2025	2030
Fish	5%	15%	25%
Milk	2%	5%	7%
Meat	3%	6%	9%
Egg	5%	9%	13%

- Integrated Farming System (IFS) approach is to be adopted and popularized for optimal utilization of the resources, particularly among the small and marginal farmers.
- Agro-climatic zone wise inter-related/interlinking farming systems including field & horticulture crops/livestock/fisheries/poultry etc. to be identified and promoted. Integration of livestock with agriculture for feed and fodder
- Training and demonstration to farmers, entrepreneurs, farmers cooperatives, FPOs, etc. on the concept of IFS.
- Strengthening of successful ongoing schemes like Backyard poultry, duckery and quail farming especially among marginal farmers, landless, SC & ST families
- Promotion of cluster based model for commercial integrated farming. Promotion of PPP for innovation in technology for integrated farming practice

5.2.6.2 Breed Improvement

- Genetic up-gradation program of indigenous varieties to be taken up.
- 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.
- Nutrient inputs determine health and productivity of livestock. Improved access to quality fodder and feed supply is critical for increasing farm level production and profitability
- Community linked Fodder Bank to be set-up in each sub-division
- Infrastructure upgradation of feed processing units & testing
- Modernization of feed producing units

[75] Draft Vision Plan Page 127-128

5.2.6.3 Increased emphasis to be laid on animal health care

- Vaccination and interventions like augmenting cattle with Water sprinklers, extension of animal health care services through mobile veterinary clinics and veterinary dispensaries under public-private partnership model.
- Mobile Veterinary Dispensaries to be set-up at block level with a target of 50% coverage of total blocks. Access to such services may be enhanced by integrating it with existing farmer advisory platforms as Kisan Call Centre (KCC). Similarly, poultry vehicle washing station in each block will be set up as a preventive measure against spread of disease etc

5.2.8 Other Possible Actions

- Improving the feed and fodder production in the State
- Improving the milk productivity by appropriate intervention when THI is high
- Enhanced training for control of vector borne disease among the live stock due to adverse weather conditions
- Awareness Generation and establishment of feedback mechanisms for veterinary services
- Research/ activities to ensure fish productivity and livelihood security.

5.3 Fisheries

West Bengal is a maritime State. It has diverse fisheries resources spreading from the marine junction in the Bay of Bengal in the south to the cold water region at the base of the Himalayas in the north[76]. West Bengal is home to several types of fishery resources broadly divided into the Inland and Marine sectors. The inland sector is further categorized as impounded water systems (ponds/tanks, beel & boar, brackish water fishery, sewage fed fishery) and open water systems (reservoir, river, canal, estuary). The marine sector is made up of inshore area (upto 10 fathom deep), offshore area (10-40 fathom deep), continental shelf (upto 100 fathom deep) and the coast line.

5.3.1 Sector Profile

West Bengal is also one of the leading states in fish exports. West Bengal has the largest brackish water resources for shrimp farming in the country and is one of the leading exporters of shrimps from India. The foreign exchange earned through export of fish food products increased to Rs 3,439.29 crores in 2014-15 (91,263 tons) from Rs 1,737 Cr. (61,915 tons) in 2011-12. 3.5 % of the population of the state i.e. about 3.235 million people are fishermen. 42% of fishermen are women. Co-operative Societies play a significant role in this sector. A total of 1,170 Fishermen Co-operative Societies (including 191 Ornamental Primary Fishermen Co-operative Societies), are operating in the inland sector, 116 marine fisheries are functioning in South 24 Parganas and 64 in Purba Medinipur in the marine sector. Table 5.4

[76] Hand Book of Fisheries Statistics 2015-16, Department of Fisheries, Directorate of Fisheries Government of West Bengal

and Figure 5.3.1 provides an idea about the distribution of fishes in impounded water systems and Open Water systems

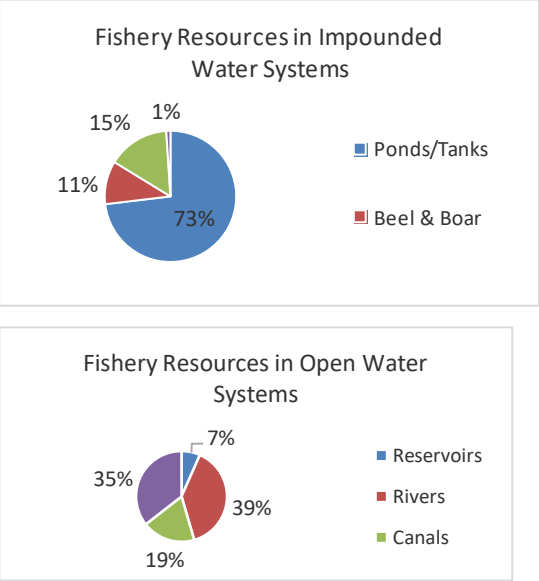


Figure 5.3.1: Fishery Resources Distribution[77]

Table 5.5: Description of Fisheries Resources

Marine Environment	**Area**
Inshore area	777 Sq. km
Offshore area	1,813 Sq. km
Continental shelf	17,049 Sq. km
Coast line	158 km

Some of the key species found inland include Major Carps, Minor Carps, Exotic Carps, Murrells, Catfishes and Hilsa. Key marine species include Sea Catfishes, Sciaenidae, Hilsa, Mugilidae, Engraulidae among others[78].

The fisheries sector provides livelihoods to 3.2 million fishermen in the State i.e. 3.5% of the total population and contributed 2.65% to the Gross State Domestic Product at constant prices (2004-05) in the year 2014-15[79]. Fish production in the state has been showing an increasing trend. The estimated fish production in the year 2014-15 was 16.17 lakh ton[80]. The majority of this (14.92 lakh ton) came from the inland sector while the rest came from the marine sector. West Bengal is the country's largest fish

[77] Hand Book of Fisheries Statistics 2015-16, Department of Fisheries, Directorate of Fisheries Government of West Bengal
[78] Hand Book of Fisheries Statistics 2015-16, Department of Fisheries, Directorate of Fisheries Government of West Bengal
[79] Statistical Abstract, 2015, Bureau of Applied Economics and Statistics, Department of Planning, Statistics and Programme Monitoring
[80] Hand Book of Fisheries Statistics 2015-16, Department of Fisheries, Directorate of Fisheries Government of West Bengal

seed-producing state. In 2015-16, production reached 17,521[81] million. Shrimp production in West Bengal has also shown an upwards trend and stood at 1,18,181[82] tons in 2015-16.

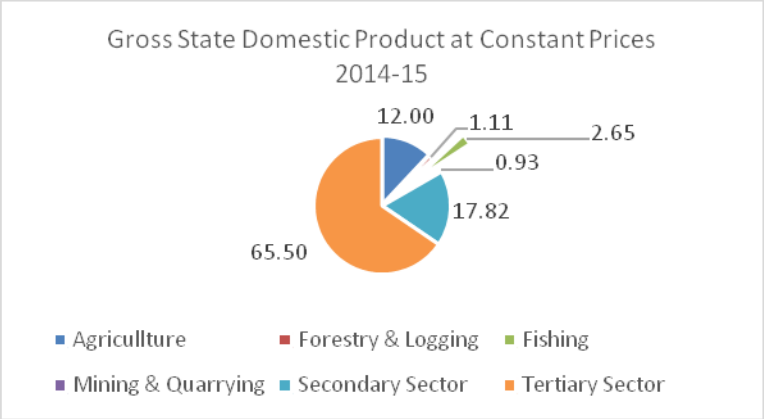


Figure 5.3.3: Gross State Domestic Product at Constant Prices (2004-05) in 2014-15[83]

5.3.2 Major Impacts Envisaged in SAPCC 2012 for Fisheries

The vulnerability index for the fisheries sector of West Bengal indicates that the sector is very susceptible to climate change[84]. Impacts of climate change on the sector include: reduction in fish seed availability, changes in the growth rate of fish, shifts in breeding period of fish and changes in the geographic distribution of fish. These impacts directly affect the ecosystems, food supply, nutritional security, livelihoods and the economic outputs of the State. Strategies devised to combat the impacts of climate change on the fisheries sector of the State include the following strategies[85].

5.3.3 Summary of Adaptation Strategies and Key Achievements taken in Fisheries Sector

- Area expansion: Pisciculture has been started in about 35,000 ponds excavated under "Jal Dharo Jal Bharo" programme in the last four years
- Distribution of quality fish seed: To increase production during the last six years about 1,500 lakh quality fish fingerlings have been distributed in about 60,000 ponds
- Distribution of fish feed: Since 2014-15, an initiative has been taken to supply nutritionally balanced floating feed, free of cost to fish farmers. 16,200 MT of fish feed has been distributed to about 25,000 fish farmers in West Bengal with a financial involvement of about Rs. 45 crore
- Development of Jhora Fisheries: 2000 jhora fisheries have been brought under pisciculture, in order to develop cold water fishery in the hilly areas of the state

[81] Hand Book of Fisheries Statistics 2015-16, Department of Fisheries, Directorate of Fisheries Government of West Bengal
[82] Hand Book of Fisheries Statistics 2015-16, Department of Fisheries, Directorate of Fisheries Government of West Bengal
[83] Statistical Abstract, 2015, Bureau of Applied Economics and Statistics, Department of Planning, Statistics and Programme Monitoring
[84] Annual Report ICAR-NPCC, 2009-10, Central Inland Fisheries Research Institute
[85] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal

- Setting up Integrated facility: Facility built at Deshapran Fishing Harbour, Petuaghat, Purba Medinipur for storage and processing of fish and sea foods along with 200 MT cold storage, blast freezer of 10mt/day, pre-cooling chamber of 10 MT and other primary processing facilities. Dry-Fish Processing Centre has also been set-up and operationalized at Junput, Purba Medinipur.
- Research and Development:
- For the first time a consortium was formed with all ICAR Fisheries Institutes for addressing R&D needs in fisheries sector and on this platform, a 'Disease Surveillance' Project (the first of its kind) has started functioning in 10 districts of the state.
- Hilsa Conservation and Research Centre (HCRC) has been set up at Sultanpur, to address the declining trend of Hilsa fishery over the past decade
- Construction of Block level Laboratories have been completed in 288 Blocks. Construction is in progress for another 20 laboratories. At the same time, 212 Hatcheries have been accredited and certified.
- Conservation of indigenous local fish: Steps have been taken to conserve indigenous fish (i.e. Pabda, Saral punti, Deshi tangra, Mourala, Chital, Folui etc.) in water bodies like beels, backyard ponds etc. Special emphasis has been given to increase the production of Deshi Magur

Key Achievements

- The fish production has increased to 1.72 million tonnes at annual growth rate 3.36 percent.
- Pisciculture has been started in about 35,000 pond excavated under Jal Dharo Jal Bharo programme
- Distress Allert Transmeter has been introduced. 3,656 transmitters have been distributed. 11,912 certificates have been issued for e-registration of fishing vehicles.

Figure 5.3.4: Key Achievements of Fisheries in Context of Climate Change up to 2016

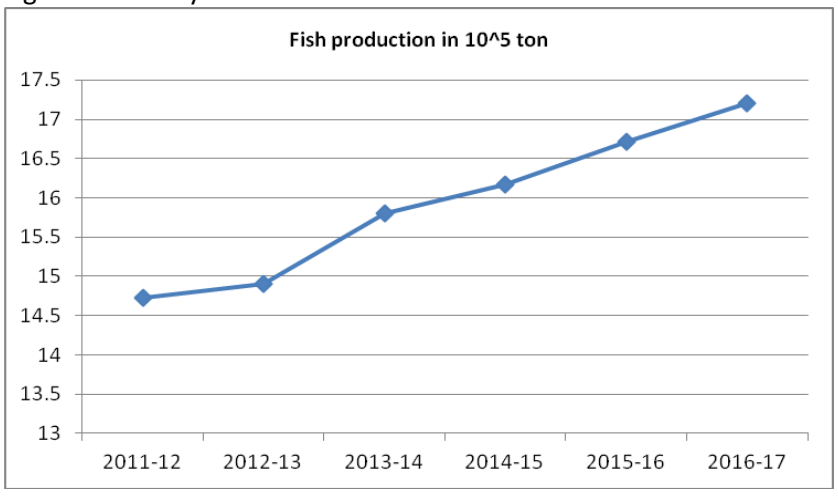


Figure 5.3.2: Gross State Domestic Product at Constant Prices (2004-05) in 2014-15[86]

5.3.4 Impacts envisaged in 2017

Figure 5.3.1 suggests that ponds and river has major portion of fishes in the state. The availability of water varies and is dependant largely on rainfall, which is also skewed across geographical areas and across seasons. Low fish production in the districts of Jalpaiguri, Murshidabad, Nadia, Haora, Puruliya, Bankura, and Paschim Medinipur is co-related to less rainfall coupled with low moisture holding capacity in the soil. As mentioned in section 5.3.2, lesser precipitation and warmer climate may negatively impact the productivity of fish and is likely to alter the fish breeding and spawning time. This again has sequential effects in food chains. Fishes are cold blooded (polikilotherms). The metabolic rates of fishes are significantly controlled by temperature. Fry (1971)[87] showed the thermal tolerances of fish can be classified as "lethal", "controlling" and "directive" responses and the physiological cycle of fish starts responding to rising temperatures of water long before it reaches "lethal" level. Further, fish species are integral part of the food web and the fish population is also dependent of other aquatic lives, which also get affected by higher temperature. Optimal temperature for common fishes of West Bengal like Labeo Rohita[88], Shrimp and Tilapia[89] are in 22-31^{0}C. The seasonal changes need to be understood with further details. As warmer summer months may have lesser production but warmer winters may offset the impacts.

5.3.5 Actions and Targets adopted by the Department

- Nineteen lakh metric tonnes of fish production by 2022, in spite of impending climate adversities
  - Increase culture area coverage through renovation of beels/ boars (100 ha), renovation of semi -derelict /derelict tanks/ ponds (50 ha), estuarine resources.
  - Target of higher production by 2,050kg /ha /yr in FFDA ponds, and 700kg in non-FFDA ponds.
  - Emphasis to be given on enhancement of fish production and productivity by way of establishing fish hatchery, ponds and tanks. Accreditation of private hatcheries to be undertaken for ensuring quality fish seed production and standardized supply quality.
  - Proper management of hatcheries for carp (to mitigate in- breeding depression) and air breathing fish seed production

[86] Statistical Abstract, 2015, Bureau of Applied Economics and Statistics, Department of Planning, Statistics and Programme Monitoring

[87] Fry, F.E.J. 1971. The effect of environmental factors on the physiology of fish.
In W.S. Hoar & D.J. Randall, eds. ,Fish physiology, Vol. 6. pp. 1–98. New York, USA, Academic Press

[88] Das M.K., Srivastava P.K., Dey, S, Modal L, Mukhopadhya M.K., Saha P.K "Impact of Temperature Change on Growth of Labeo Rohita: Development of a growth Model, J. Inland Fish. Soc. India, 45(1):41-43, 2013, http://www.academia.edu/7703249/Impact_of_temperature_change_on_the_growth_of_Labeo_rohita_development_of_a_growth_model

[89] http://www.fao.org/fileadmin/user_upload/newsroom/docs/FTP530.pdf, page176

- Special emphasis to be given for increasing fish production in less fish-producing districts compared to available area, like Darjiling (Siliguri), Jalpaiguri, Koch Bihar, Maldah, South 24 Parganas, Puruliya and Bankura
- Seasonal aquaculture to be encouraged (fingerlings rearing, magur culture) in rainfed ponds of Jangal Mahal, Birbhum.
- Culture in ponds under Jal Dharo Jal Bhoro Scheme.
- Identification, conservation and upgradation of indigenous fish genetic resources including ornamental fishes.
- Fish Brood Banks to be set-up for improving brood stock.
- Mapping of aquaculture zone across agro-climate and developing zone specific technology.
- Mangrove based culture system may be developed with a programme on a in pilot scale as sustainable practices through community linked participation
- Capacity and competency development of farmers through extensive training and field demonstrations
- Promoting soil and water / tank health cards
- Provide technical and financial assistance to farmers to encourage them to adopt best practices and culture high yielding varieties of fish
- Augmenting credit facilities and insurance schemes and related services to support fisheries sector

5.3.6 Other Possible Actions

- Distribution and development of quality fish seeds
- Setting up fish seed markets and integrated facilities
- Mapping of vulnerable fisher folks
- Forecasting/ training and data generation on fishery
- Development of sewage fed fisheries
- Protection and development of water bodies
- Providing life saving gears and tracking equipments.
- Block level laboratory cum training centre for fishery extension officers
- Research/ activities to ensure fish productivity and livelihood security

5.4 Food Processing Industries and Horticulture (FPI&H)

5.4.1 Sector Profile

West Bengal's horticulture sector has the potential for larger production, area expansion, generation of self-employment, processing, packaging, transportation, marketing as well as export. The sector is made up of the production of fruits, vegetables, cut flowers, loose flowers, spices, and plantation crops. The key varieties of each along with their area, production and productivity in 2013-14 are given in the table below. West Bengal is ranked 9th in fruit production in the country, in fact, more and more marginal

farmers are taking up the production of short duration fruits[90]. It is also ranked 1st in vegetable production in the country[91]. However, it terms of vegetable productivity it was ranked 8th (16.7 tonnes/ha compared to the national average yield of 17.34 tonnes/ha)[92].

Table 5.6: Varieties, Area, Production & Productivity of Horticultural Crops In West Bengal[93]

Key Crops	Key Varieties	Area ('000 ha)	Production ('000 MT)	Productivity Mt/Ha
Fruits	Mango, Banana, Pineapple, Papaya, Guava, Jack Fruit, Litchi, Mandarin Orange, Sapota, etc	223.5	2909.71	13.019
Vegetables	Tomato, Cabbage, Cauliflower, Peas, Brinjal, Onion, Ladyfiner, Sweet Potato, Beans, Cucurbits, Radish, Watermelon, Ol, Kachu etc	968.050	14014.950	14.478
Flowers	Rose, Chrysanthemum, Gladiolus, Tuberose, Marigold, Jasmine, etc	24.850	261.35 Crore Sticks	
Spices	Dry Chilli, Ginger, Tumeric, Large Cardamom, Garlic, Black Pepper, etc	117.097	66.500	2.745
Plantation Crops	Coconut, Areacanut, Betelvine, Cashewnut etc	72.475	321.462	

The fruits, flowers and spices having potentiality to be grown on commercial basis in different agro-climatic zones of West Bengal are given in the Table 5.7 below.

Table 5.7: Potential fruits, flowers and spices of different agro-climatic zones[94]

Agro-climatic Zones of WB	Fruits	Flowers	Spices
Hill Zone	Orange, Strawberry etc.	Orchid, Gladiolus, Gerbera, Anthurium, Foliages, Cactus, Succulents, Different flowers	Black cumin, Fennugreek, Coriander, Chilli, Turmeric, Ginger, Large cardamom

[90] State of Environment Report West Bengal, 2016, State Pollution Control Board
[91] State of Environment Report West Bengal, 2016, State Pollution Control Board
[92] State of Environment Report West Bengal, 2016, State Pollution Control Board
[93] Directorate of Horticulture , 2013-14
[94] Adhunik Uddyan Bijnan Prajukti (2016), faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya

Agro-climatic Zones of WB	Fruits	Flowers	Spices
Terai Zone	Pineapple, Jackfruit, Coconut, Arecanut, Banana etc.	Marigold, Tuberose, Foliages, fern, Gerbera in polyhouse etc.	Fennel, Coriander, Chilli, Turmeric, Ginger, Black pepper
New& Old Alluvial Zone	Mango, Guava, Papaya, Litchi, Banana etc	Tuberose, Marigold, Roses, Jasmines, Dahlia, Gerbera, Anthurium, Gladiolus etc.	Black cumin, Fenugreek, Fennel, Coriander, Garlic, Black pepper, Chilli, Turmeric, Ginger
Red Lateritic Zone	Mandarins, Ber, Mango, Pomegranate, Guava, Grapes, Cashewnut etc.	Hibiscus, Roses, Marigold, Cactus, Succulents, Chrysanthemum, Gerbera in poly house, Anthurium etc.	Black cumin, Fennugreek, Coriander, Chilli, Turmeric, Ginger
Coastal Saline Zone	Coconut, Cashewnut, Sapota, Carambola, Karamcha etc.	Hibiscus, Marigold etc.	Black cumin, Fennugreek, Fennel, Coriander, Garlic, Chilli, Turmeric, Ginger

5.4.2 Major Impacts Envisaged in SAPCC 2012 for FPI&H

The horticulture sector of West Bengal is expected to experience huge losses due to climate changes. Potential impact[95] of climate change on the horticulture sector is projected to be a shift in the area of potential suitable zones for various horticulture crops, a change in the planting and production timing, less storage period in trees/plants (due to faster maturity induced ripening), disruption to the pollination cycle, higher irrigation requirement among many others. As a result, the following strategies have been adopted to combat these impacts[96]:

5.4.3 Summary of Adaptation Strategies Proposed in SAPCC 2012

- Provision of heat shade to all fruit trees and construction of greenhouses for vegetables
- Research and Development of climate smart horticulture crops
- Popularizing indigenous varieties

[95] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal
[96] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal

- Crop diversification
- Improvement of floriculture programmes
- Production of off-season vegetables
- Integrated Pest Management (IPM)
- Undertaking Water Management Programmes
- Reducing weather related risk by establishing weather stations
- Improvement of storage and transport infrastructure

5.4.4 Key Achievements of FPI&H in Context of Climate Change up to 2016

- Weather Based Crop Insurance Scheme (WBCIS) is taken up as a major thrust area to provide financial support s in the event of natural calamities and adverse weather conditions. 32,667 nos of farmers have been covered. Total sum assured is Rs.4,494 lakh .
- 195 water harvesting structure has been created for plantation of horticultural crops.
- Inspite of unforeseen changes in weather, the production of horticultural crops (fruits, vegetables, flowers, spices) has increased with a cumulative growth of 9.9 percent.
- On an all India basis , the state of West Bengal ranked first in respect of annual production in Pine apple (330070 MT), Brinjal (3003580 MT), Okra (505450 MT), second in Potato (8427300 MT) and third in Sweet potato (2,39,810 MT) and Ginger (1,29, 020 MT)

5.4.5 Impacts envisaged in 2017

Temperature increases associated with climate change will impact horticultural commodities and regions through all of the following[97]:

- Changes in the suitability, availability and adaptability of cultivars;
- Changes in the optimum growing periods and locations for horticultural crops;
- Changes in the distribution of existing pests, diseases and weeds, including an increased
- threat of new incursions;
- Increased incidence of disorders such as tip burn and blossom end rot; and
- Greater potential for downgrading product quality because of increased incidence of sunburn.

Critical Temperature Threshold for different horticultural products is different. Table 5.4.1 provides an idea about the critical temperature thresholds. Critical Temperature Threshold is a temperature threshold of a viable product beyond which production becomes unviable. However, temperature is not the sole governing parameter. Unseasonal rains can trigger pest attack and may also cause serious damages. Temperature tolerance of Mango may ranges up to 48 ^{0}C [98] but rain during pre-flowering and flowering period can lead to poor fruit set and weak pollination. A thorough understanding of the

[97] Peter Deuter et al, "Critical (temperature) thresholds and climate change impacts/adaptation in horticulture", Department of Employment Economic Development and Innovation (DEEDI), Queensland, Project Number :- QP1005130 (1/5/2011)
[98] http://www.academia.edu/28547466/Article 21_Impact_of_climate_change_on_phenology_of_Mango_The_case_study

impacts of like changes in each of the above-mentioned products can help the cultivars to quickly adapt to ensuing changes.

Table 5.8: Critical Temperature Threshold for Select Fruits

Crop	Development Phase	Critical Temperature Threshold
Banana	Fruit maturity	38^0C
Citrus	Early fruit development	30^0C
Pineapple	Flower initiation and pre-harvest	35^0C

Intelligent planning can enable the cultivars to reap off the benefits of a temperature rise by selection of the appropriate fruit. As for example banana production is expected to increase in warmer climates[99].

5.4.6 Ideal Strategies for FPI&H Sector

- Establishing a practical understanding of critical temperature thresholds of significance to specific horticultural crops and production regions in the state
- Using this understanding to identify commodities and/or regions which, under climate change, are or will be significantly impacted by increasing temperatures
- Assessing the impacts on production systems and/or regions, and identify adaptation strategies to address these impacts.
- Understanding impacts of other meteorological parameters
- Identify those commodities and regions which will be most impacted by further rises intemperature (and decreases in rainfall runoff), and potential new or alternative locationswhere temperatures will be more favourable, up to and after 2030
- Identify those countries/regions which currently export products to West Bengal, which will be significantly impacted by rising temperatures, and those which will become more competitive in the West Bengal market because of favourable impacts as a result of further changes to the world's climate.
- The growers and industry need to be vigilant in continuing to assess the changes in climate as they occur, and the impacts these changes will bring.

5.4.7 Actions and Targets adopted by the Departments[100]

Target: Increase in percentage growth in per capita availability of vegetables and fruits by 1% (2020), 5% (2025) and 7% (2030), Reduction in food losses by 10% by 2020, 8% by 2025 and 6% by 2030.

Increase in area of Horticultural Crops

[99] https://www.bioversityinternational.org/news/detail/bananas-and-climate-change-what-is-going-to-happen-to-one-of-the-worlds-favourite-fru

[100] State Plan Draft for Discussion page 129

- Timely and Quality Seed Supply
- Promotion of Nutrient Management Technologies and Plant Protection Technologies Practices
- Promotion of balanced plant nutrients including micronutrients and good horticultural practices
- Strengthening the soil testing facilities by establishment of mobile soil testing laboratories, maximizing farmer linkages for issuance of soil health cards is to be made a priority
- Integrated Pest Management system practices to be adopted
- Bio-security (safeguarding biological resources from external threats) for better prevention against diseases through improved communication across stakeholders to be practiced

- **Others:**
  - Setting up model centres across the State to boost up the commercial cultivation of ornamental plants.
  - Farm equipment for Horticulture – flower and fruit plantations, plantation crops, agro-forestry, livestock rearing and allied sub-sectors will be encouraged

5.4.8 Other Possible Actions

- Provision of heat shades to all fruit trees and construction of greenhouses for vegetables
- Research and Development of climate smart horticulture crops
- Popularizing indigenous varieties
- Crop diversification
- Improvement of floriculture programmes
- Production of off-season vegetables
- Integrated Pest Management (IPM)
- Undertaking Water Management Programmes
- Improvement of storage and transport infrastructure

6.0 Forest

6.1 Description and Status of Forest

West Bengal has a recorded forest area of 11,879[101] sq km which covers 13.38[102] % of the State's geographical area and 2.7[103]% of the Indian landmass. Of the total recorded forest area of the State, Reserved Forests constitute 59.38 per cent and Protected Forests 31.75 per cent; the remaining forest area is Unclassed State Forest[104].

[101] State of Environment Report, 2016, West Bengal Pollution Control Board
[102] State of Environment Report, 2016, West Bengal Pollution Control Board
[103] State of Environment Report, 2016, West Bengal Pollution Control Board
[104] State of Environment Report, 2016, West Bengal Pollution Control Board

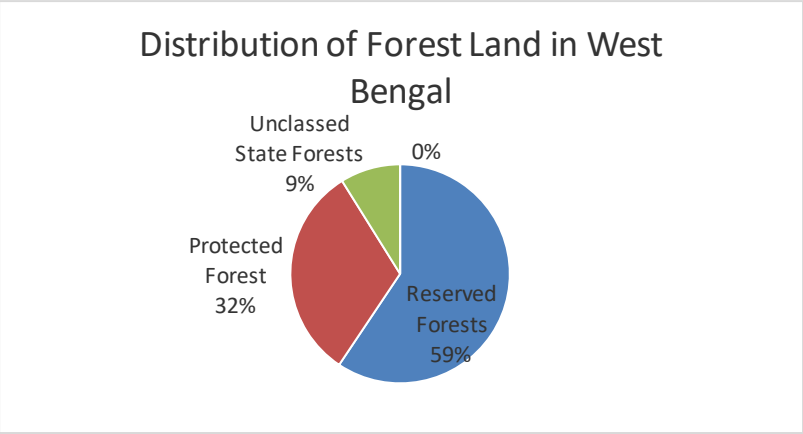


Figure 6.1: Distribution of Forest Land in West Bengal[105]

Diverse climatic conditions in the state have given rise to diverse types of forest types and ecosystems. West Bengal is the only the state in India to have both coastal and alpine ecosystems. It has eight forest types, viz, Tropical Semi-Evergreen forests, Tropical Moist Deciduous forests, Littoral and Swamp forests, Tropical Dry Deciduous forests, Sub-tropical Broadleaved hill forests, Montane Wet Temperate forests, Himalayan Moist Temperate forests and Subalpine forests.[106]

Table 6.1: Forest types of West Bengal[107]

Forest Type	Area (sq.km)	Locations	Major Species
Tropical Semi-Evergreen Forests	357.50	Jalpaiguri district	*Shorea robusta, Michaelia champaca, Terminalia myriocarpa, Ailanthus grandis,Phoebe spp.*
Tropical Moist Deciduous Forests	1376.19	Duars and Terai area of North Bengal	*Shorea robusta, Michelia champaca, Lagerstroemia parviflora, Terminalia belerica, Chukrasia velutina.*
Littoral and Swamp forests	2120.08	North 24 Parganas and South 24 Parganas districts	*Ceriops spp., Avicennia spp., Rhizophora candelaria etc.*
Tropical Dry Deciduous Forests	3575.70	Bankura, Puruliya,	*Shorea robusta, Anogeissus latifolia, Boswellia serrata, Terminalia belerica,*

[105] Annual Report 2014-15 of the Directorate of Forests, Government of West Bengal
[106] State of Environment Report, 2016, West Bengal Pollution Control Board
[107] Annual Report 2014-15 of the Directorate of Forests, Government of West Bengal

Forest Type	Area (sq.km)	Locations	Major Species
		Medinipur, Birbhum, Barddhaman	*T.tomentosa*
Subtropical Broadleaved hill forests	339.41	North Bengal hills (300 m-1650 m)	*Schima wallichi, Castanopsis indica, Phoebe attenuata, Castanopsis tribuloides*
Montane Wet Temperate forests	200.31	North Bengal hills (1650 m-3000 m)	*Quercus spp., Acer spp., Machilus spp.,Michelia spp*
Himalayan Moist Temperate forests	295.36	North Bengal hills (1500 m-1800 m)	*Michelia exels, Abies densa, Tsuga brunoniana, Rhododendron spp., Arundinaria malinga, Machilus spp., Acer, Quercus etc*
Sub-alpine forests	14.21	North Bengal hills (3000 m-3700 m)	*Tsuga brunoniana, Picea spp., Abies densa, Quercus spp., Juniperus spp., Rhododendron spp and Betula utili.*

The forests occur mainly on the slopes of the Darjiling Himalayas, the Himalayan foothills, the lateritic tracts in the southern part of the State, and in the Sundarban delta region. They are a source of timber, fuel wood and several non-wood forest products. The forests are rich in biodiversity and harbor a wide variety of plants and animals. The State has 53 per cent of bird species, 47 per cent of mammals, 32 per cent of reptiles and 21 per cent of angiosperms recorded in India[108]. These include the Bengal Tiger, Asian Elephant, Bison, one-horned Rhinoceros, Himalayan Black Bear, Red Panda and many other endangered species of animals.

In order to conserve the unique biodiversity of the State, a network of protected areas has been created. The State has five national parks, fifteen sanctuaries, two tiger reserves, two elephant reserves, and one biosphere reserve. The total area under the protected area network is 4,064 sq km which amounts to 34 per cent of the total forest area and 4.54 percent of the total geographical area of the State[109].

[108] State of Environment Report, 2016, West Bengal Pollution Control Board
[109] State of Environment Report, 2016, West Bengal Pollution Control Board

6.2 Major impacts envisaged in SAPCC 2012

Studies[110] have shown that India's forest are vulnerable to climate change, the effects of which are gravely felt by the those dependent of the forest for livelihoods as well as for the wildlife. Shifting of vegetation, changes in timing of seasonal events, changes in life cycles of wildlife, increase in man and animal conflict, impacts on access to energy are envisaged as major climate change threats in SAPCC 2012.

To combat the effects of climate change in the State, 9 strategies have been devised in line with the Green India Mission. They are as follows[111]:

6.3 Summary of Adaptation Strategies Proposed in SAPCC 2012

- Spring recharge and enhancing ground water recharge in forest areas
- Enhancing quality of moderately dense forests, open forests, and degraded forests
- Linking Protected areas
- Mitigating impacts of landslides, storm surges and fast river run off
- Enhanced fire prevention and fire management
- Preventing man-animal conflict
- Understanding long term impacts of climate change on forests and monitor the health of
- forests and its C sequestration potential
- Faster penetration of renewable energy technologies for energy
- Protecting livelihoods dependent on forest products

6.4 Key Achievements in Context of Climate Change Adaptation

- The forest cover of the state has been increasing during 2011 to 2014. It has gone up by 3810 sq km i.e. 4.29%, which is highest in the country112.
- The department has afforested 72,697 hectares of forest area during 2011-2017 and work on soil moisture conservation. It has also created production capacities of 2 crore planting stock through 'Modern nursery' thereby replacing almost the entire capacity of conventional nurseries113.
- A programme "Sabujshree" has been launched to provide a sapling to every new born child in the state to inculcate emotional bonding between a child and nature[114].

[110] Impact of climate change on Indian forests: a dynamic vegetation modeling approach (2011), R.K. Chaturvedi et al.
[111] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal
[112] Draft vision document of forest
[113] Draft vision document of forest
[114] Draft vision document of forest

6.5 Impacts envisaged in 2017

In addition to the threats identified in SAPCC 2012, upward migration of species in hills, extinction of species, losses in ecosystem reserves can be the other threats faced due to climate change.

6.6 Ideal Strategies for Forest Sector

- Enhance Quality and Productivity of natural forests115
- Understanding the climate change threats faced by different species living in the forests and implantation of conservation measures
- Afforestation and reforestation and assisting natural regeneration of the forests would be taken up to create an additional carbon sink while increasing the forest and tree cover and enhancing ecosystem services.
- Identification of vulnerable species and vulnerable areas in the context of climate change
- Creation of reserves for endangered and vulnerable species in less vulnerable regions
- Increase the productivity of forest plantations
- Forest fire prevention
- Protecting & enriching the Catchments
- Strengthen participatory forest management
- Forest management for water recycling

6.7 Actions and Targets Adopted by the Departments

State proposes to increase the green cover of the state through:

- extensive social and urban forestry activities (and also through commercial forestry activities), strip plantations along with
- preserving, restoring and enhancing the forest resources of the State
- afforesting the degraded forests and
- increasing the stock of the moderately dense forests, thus increasing the productivity of forests, especially through institutionalizing production of QPM, reduction of soil & moisture loss.

6.8 Other Possible Actions

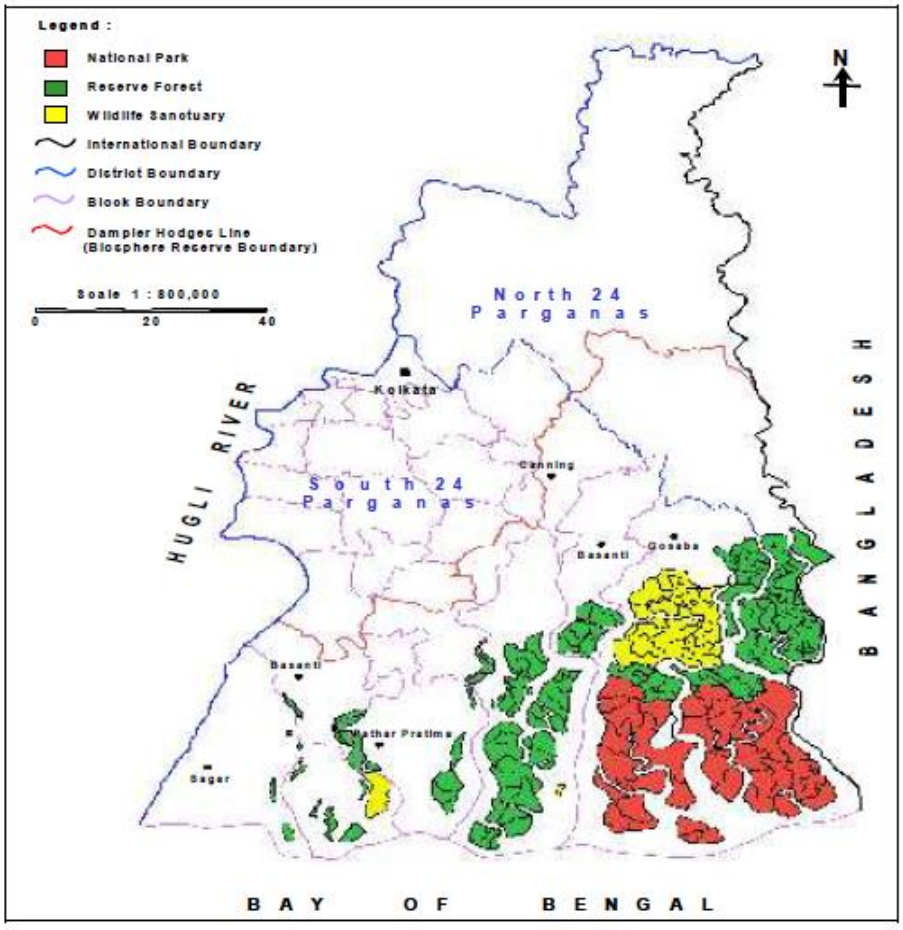
- Estimation of carbon sequestration capacity of forest areas within the state by extensive tree census and use of earth observations
- Estimating requirements of additional plantations, selection of species to enhance carbon sequestration by Forest Department to strive towards a carbon neutral West Bengal
- Estimation of utility of mangroves to act as a barrier to lessen the impacts of prevent cyclones and storm surges and
- Intensive management of wild life by use of latest information and technologies

[115] http://www.moef.nic.in/sites/default/files/Draft%20National%20Forest%20Policy%2C%202018.pdf

7.0 Sundarbans

7.1 Description

The Sundarban delta is the largest estuarine delta in the World. The Indian administrative region of Sundarbans lies within the state of West Bengal, and spreads over an area of 9,630 sq km. Of this 5,363 sq kms is reclaimed area and 4,267 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[116]. The entire mangrove area protects the inland area from the recurrent cyclonic disturbances and storm surges that occur in this area.



[116] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal

Table 7.1: Sundarbans Profile[117]

Sundarbans Profile	
Climate	Cyclone prone and monsoonal Average annual maximum temperature is around 35°C Average annual rain fall is 1,920 mm Average cyclonic events per year is slightly more than 4 of varying wind forces
Soil	Can be classified as, clay soil, heavy, soil, sandy loam, sandy soil and silty soil Salinity varies between low (up to 8ppt) and moderate to high (8 ppt- 20 ppt)
Water	7 rivers flow through the Sundarbans: Hooghly, Muringanaga, Aptamukhi, Thakuran, Matla, Gosaba and Harinbhanga Surface water in Sundarbans is saline and not potable
Administrative Area	Sundarban area lies in 2 Districts (South 24 Parganas and North 24 Parganas) covering 19 blocks, 190 Gram Panchayats and 1,064 villages
Population	43.75 lakhs (2011)
Land Use	Agriculture and homestead garden account for 65% of the land Forests account for 15% Residual area makes up the remaining 19%
Forests	Can be classified as deforested mangrove swamp, dense mangrove forests, tall & dense mangroves, brakish water mixed *Heritiera sp*. forests, palm swamps dominated by *Phoenix paludosa*
Biodiversity	The Sundarban ecosystem is one of the most biologically protective and taxonomically diverse ecosystems of the Indian Sub-continent Key endemic floral species found here include: Sundari Tree, Mangrove apple, Sea Date/Khadi Khajur etc Key endemic faunal species found here include: Royal Bengal Tiger, Spotted Deer, Wild Boar, Estuarine Crocodiles etc
Livelihood	Over 60 % of the population is engaged in agriculture Around 5 % in household industries and as artisans Remaining practice miscellaneous livelihoods such as fishery, natural resource collectors, some professionals and some provide various services
Agriculture	Kharif Season: Paddy, ladies finger, ridge gourd, bitter gourd, beans, snake gourd, and watermelons etc Rabi Season: Paddy, pulses like khesari & moong , oil seeds like sesame, mustard and sunflower
Health	People of Sundarbans are primarily affected by water and vector borne diseases 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

[117] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal

	years & women in Sundarban living in extreme poverty Diarrhoeal prevalence peaks during cyclones.
Energy	As of 2010, only 17% households were electrified. Per capita electricity consumption is low at 58.4 KWh/ year

7.2 Major Impacts Envisaged in SAPCC 2012 for the Sundarbans

The Sundarbans are in West Bengal is has a high exposure and sensitivity to climate change with a low adaptive capacity, making it a very vulnerable area. Climate changes in the area have already been observed[118]: (during 1960-2005)

- Maximum temperature has decreased by -0.50oC
- Minimum temperature has risen by 1^{o}C
- Heavy precipitation events have increased
- Winters have become drier
- Frequency of cyclonic disturbances have decreased, but intensity has increased
- Further these are projected119 to be further exacerbated in the future (until 2050's):
- Maximum temperature is projected to rise by 3.6-3.8^{o}C
- Minimum temperature is projected to rise by 1.8 to 2.0^{o}C
- 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 is likely to increase with increase in sea surface temperatures
- These changes will have wider ranging impacts on the region. Some of the key impacts are highlighted below[120]
- On Mangrove Fauna: Climate change is likely to adversely impact soft bodied animals and bivalve mollusks that are very sensitive to increasing temperatures. Marine species are also at risk from desiccation. However, the largest danger is that of habitat loss as the mangrove forests decline.
- On Health: Climate change is likely to increase the incidences of morbidity and mortality as a result of water borne diseases, cyclone damages, malaria and dengue vectors amongst others.
- On agriculture: Climate change is likely to impact agriculture in the Sundarbans as a result of an increase in soil salinity. This may lower yields which already are not enough for the burgeoning population of the region.
- On Water: Climate change is likely impact the availability of portable water for both human settlement as well as wild habitats as a result of increasing salinity.

[118] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal
[119] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal
[120] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal

Gauging the extent of these impacts, West Bengal has adopted the following adaptation strategies to cope[121]:

7.3 Summary of Adaptation Strategies Proposed in SAPCC 2012 for Sundarban

- Protection against increase in intensities of cyclones
- Protect agriculture productivity and related livelihoods
- Promote alternate livelihood opportunities
- Enhance the accessibility to drinking water
- Improve accessibility to health facilities
- Conservation of biodiversity

7.4 Key Achievements of in Context of Climate Change

- Created 430 hectre of Mangrove forest and Strip of Jhow plantation
- Constructed 800 km of all weather roads, constructed 20 nos of RCC jettiesy, 23 nos. of RCC bridges as part of improving connectivity for quick mobilization of relief and transport of, people to safe places during natural calamities as a part of development of sustainable communication[122]
- Distributed:
- humic acid and neem oil cake to 5,000 nos of beneficiaries
- sunflower and seeds of moong crop (SML-668), elephant foot yearn,
- shade net to betel vine
- different types of fingerlings to 45,000 beneficiaries
- promoted manual farm machineries like paddy threshers, hand sprayers, foot operated sprayers, use of alternative crops, salt tolerant varieties (local and high yielding)
- encouraged alternative livelihoods among young (18-25 yrs) BPL(Below Poverty line), SC/ST (Schedule Cast/ Schedule Tribe) , girl candidates.

7.5 Actions and Targets Proposed by the Department[123]

Connectivity and accessibility are difficult in this region. It has been proposed to:

- Extensive plantation of mangrove forests and creating awareness about the importance of social forestry at the school level
- Develop extended surface and water networks in the Sundarban area by undertaking construction projects of Brick paved roads, Concrete roads, Bituminous roads, bridges and culverts as connectivity and accessibility is a major problems in this region. Additionally,

[121] West Bengal State Action Plan for Climate Change, 2012, Government of West Bengal
[122] Communication from SDB in September 2016
[123] Draft vision document of forest 119 to 120

construction and renovation of jetties would be done in order to ensure swift movement through inland waterways

- Enhancing agricultural and allied inputs and implements along with extended scope of organic farming and state-of-the-art farming techniques in the Sundarban area.
- Revamping of school and market infrastructures across the region

7.6 Other Possible Actions

- Conservation of this unique mangrove biosphere
- Regular monitoring of different ecological indicators to understand the impacts of climate change on the species living in the Sundarbans
- Planning appropriate conservation measures and implementation of the same
- Implementation of coastal zone management plan

8 Health

8.1 Description

Health and Welfare: West Bengal achieved improvements in major health indicators like life expectancy at birth, which has increased from 57.4 in 1981 to 69.9 in 2013, Infant Mortality Rate (IMR) per 1000 births, which has improved from 86 in 1981 to 25 in 2016 and other parameters like child's immunization, decadal growth rate and total fertility rate. The state has invested heavily in critical care units, super-specialty hospitals, care for expecting mothers and new born children and curative and preventative care for communicable and non-communicable diseases. However, the communicable and non communicable diseases continue to be the major concern for the state[124].

8.2 Major Impacts Envisaged in SAPCC 2012 for Health Sector

- Water borne diseases; Cholera, Acute Diarrhea Disease (ADD), and Enteric fever were predicted to increase due to climate change.
- Impacts on vulnerable populations were expected to increase
- Vector borne diseases would spread in new regions
- Incidences of morbidities due to increases in extreme heat events shall increase
- Increase in intensity of cyclones shall lead to higher morbidity and mortality
- Increase in water borne diseases and respiratory diseases due to increase in pollution loads as temperatures increase would occur
- Emergence of new diseases

8.3 Summary of Adaptation Strategies Proposed in SAPCC 2012

Strategies were proposed to strengthen the health policy vis a vis climate change as follows:

- 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 institutions to address climate change related human health challenges
- Addressing Knowledge gaps

[124] Draft Vision Plan 8 to 10

8.4 Actions taken in Health Sector in context of Climate Change up to 2017

Identification of Five Diseases

Five disease conditions have been tentatively short-listed as priority areas in the context of climate change on the basis of disease magnitude in the state, the present epidemiological &/or entomological scenarios and the threats of individual diseases/ public health problems:

1) Dengue & Malaria
2) Japanese Encephalitis
3) Acute Diarrhoeal Diseases
4) Heat Stress and related impacts
5) Influenzas

Rationale for selecting the particular diseases: -

(a) Dengue

- Urban disease extending its limit to affect peri-urban & rural areas
- Disease pathology changing characteristics; more of organ involvement warranting critical care
- Change in serotypic pattern
- Change in vector predominance: Aedes albopictus gaining importance

(b) Malaria

- Parasite is likely to develop drug resistance with time
- New species may emerge
- New endemic foci may appear
- Vector may become resistant to insecticides
- Challenge of forest malaria – very difficult to prevent
- Asymptomatic malaria

(c) Japanese Encephalitis

- It is a notifiable disease
- Case fatality is very high i.e. 20 to 30%
- The percentage of disability is also high among the survivors.
- Trend analysis shows seasonal patterns in North and South Bengal zones.
- As it is a vaccine preventable disease, even if climatic factors get altered, vaccination may help in its prevention.

(d) Acute Diarrhoeal Diseases (including cholera and dysentery):

- Threat of emergence of new virulent strains of pathogen
- Development of drug resistance in bacteria
- Risk of contamination of water sources during climatic adversities, affecting both natural and man-made sources

(e) Heat Stress & Related Impacts:

- As heat related events are being reported almost regularly during the summer months, thus it is an impending problem.

- In last few years drastic increases in temperatures have been noted which is causing significant impact on public life.

(f) Influenza:

- Notifiable disease.
- Previously it was seen that upsurge in cases was only during the rainy season (July – October) but currently two trends have been noted one during rainy season and the other during late winters.
- Round the year cases are been noted.
- High risk disease.

Identified Diseases	**Identified Districts**	**Projects/Programme**	**Departments/Institutions involved**	**Action Taken**
Dengue	N24 Pargs, S24 Pargs, Nadia, Darjiling, Murshidabad	N.V.B.D.C.P. State funded activities	Health & FW, Municipal Affairs, P & RD, NICED (ICMR)	H-T-H Survey in selected Urban Areas, fortnightly, May to October (2017); now in this year 2018 fortnight survey will take place annually (Jan. – Dec.). Surveillance through public & private reporting units and serotyping. Entomological Surveys are being done to raise alert and monitor the vector control activities. Analysis of IDSP (Integrated Disease Surveillance Programme) weekly reports to prioritize the sensitive areas and continue surveillance to capture any EWAR/OB. Prompt actions are being taken by RRT members. Feed back from IDSP to programme officers of disease control programme for targeted action. Capacity building of health care providers for case management. Strengthening of disease surveillance, involving both public & private facilities. House-to-house breed checking & fever surveillance in 125 selected municipalities and also villages facing upsurge of dengue. Serotyping and monitoring of changes in collaboration with NICED. Strengthening of vector surveillance 49 posts of Dist. Entomologists created; and 43 joined. Induction training given to them.

Identified Diseases	**Identified Districts**	**Projects/Programme**	**Departments/Institutions involved**	**Action Taken**
Malaria	Jhargram, Purulia, Bankura, West Midnapur, Alipurduar	N.V.B.D.C.P. State funded activities	Health & FW, Municipal Affairs, P & RD	Strengthening of case detection mechanism. Strengthening of surveillance for identification of high endemic areas & new foci. Mobile Medical Camps in high endemic villages. Audit of each malaria death. Entomological survey, including assessment of IRS spray. Provisioning of LLINs. Already LLINs distributed in the high endemic areas of districts like Puruliya, Bankura, Jhargram, Paschim Medinipur etc . Drug sensitivity study initiated by N.I.M.R. Mobile medical camps in 45 endemic blocks. Survey for malaria in some of the forest villages in Puruliya, Bankura & Jhargram. Survey for asymptomatic malaria in several villages. Study of vector for insecticide resistance.
Japanese Encephalitis	Koch Bihar, Jalpaiguri, Birbhum, Purba Burdwan, Uttar Dinajpur	N.V.B.D.C.P. Routine Immunization	Health & FW, P & RD, ARD	Gearing up of laboratory based surveillance. Strengthening JE-vaccination. Public awareness generation on: vector breeding reduction, personal protection against mosquito bite & vaccination. Capacity building for case management.
	N24 Pargs, S24	IDCF (under RCH)	Health & FW	Special care of sensitive population (pregnant individual,

Identified Diseases	**Identified Districts**	**Projects/Programme**	**Departments/Institutions involved**	**Action Taken**
Ac. Diarrhoeal Diseases	Pargs, Nadia, East Midnapur, Puruliya	State funded activities	NICED (ICMR) Education	pediatrics, geriatrics, immunocompromised patients and terminally ill patients). Guiding the management of cases with a protocol. Capacity building for Medical Officers & Nurses for rational case management. Death Audit. RRT at block level catering to the emergencies (outbreaks). Monitoring of trend of isolates with inputs from NICED & several Medical College Labs. Evidence based antibiotic policy for cholera & bacillary dysentery. Monitoring for EWS-s & media scans for prompt identification & outbreak response.
Heat Stress & Related Impacts	Puruliya, Bankura, West Midnapur, Paschim Burdwan, Birbhum	State funded activities	Health & FW P & RD Municipal Affairs	Issuance of directives; percolation up to block level. Capacity building for hospitals Daily reporting for casualties to heat IEC/BCC for population specially at risk.
Influenza	N24 Pargs, S24 Pargs, Nadia, Haora,	I.D.S.P. V.R.D.L. State funded	Health & FW	State run programme. Reserve stock of medicine and other logistics are maintained at district level; [medicine for treatment of

Identified Diseases	**Identified Districts**	**Projects/Programme**	**Departments/Institutions involved**	**Action Taken**
	Hooghly	activities		cases and chemoprophylaxis]. IEC done. Surveillance. Daily reporting.

Another area which is cross-cutting in nature and very sensitive & important in the public health point of view, where emphasis has been given as one of the climate change related initiatives is identification, notification & response to outbreaks of communicable diseases.

Outbreak of communicable diseases

- ❖ Lab support for aetiological diagnosis :
  - o Major and daily inputs from I.D.S.P.
  - o Resource persons are being hired; empty positions for epidemiologists recruitment has been initiated (and for microbiologists)
- ❖ Rapid Response Teams :
  - o In position at state & district level. Formation at block level is under process (guidelines given).
  - o Prompt and effective response through RRT for the outbreak.
  - o Involvement of A.R.D. Dept. in the RRT-s. Inclusion of experts in the State-RRT.
  - o Monthly review done at the state level.
  - o Training of Block RRTs included in P.I.P. for this year.

8.6 Actions and Targets adopted by the Departments

The Government of West Bengal had taken a decision to establish Critical Care & High Dependency Units all over West Bengal targeting to ensure Critical Care and Emergency management with advanced life-saving facilities at a distance of every 50 Km. One of the targets is to reduce the mortality related to vector borne diseases like Dengue, Japanese Encephalitis and others.

- Ensure universal access to healthcare for substantial reduction in child and maternal mortality indicators:
- Respond promptly to epidemics of communicable diseases and significantly reduce premature mortality from non-communicable diseases through a holistic system of curative and preventive healthcare:
- Respond promptly to diarrhea outbreaks through
  - o Capacity building of Medical Officers & Nurses on protocol based management of acute diarrhea cases
  - o Collection of clinical samples in at least 85% of diarrhoea outbreaks for detection of the causative organism
  - o Establishment of a network of Referral Labs (in Medical Colleges) & Public Health Labs (in selected District Hospitals) to provide laboratory back-up for investigation of acute diarrhea outbreaks
  - o Observance of Integrated Diarrhea Control Fortnight (IDCF) and Deworming Days at par with national guideline
  - o Evidence based antibiotic policy for cholera/ bacillary dysentery

- Eliminate Kala Azar and post-elimination surveillance for sustenance of achievements in kalaazar, including,
- Prevention of re-introduction of VL transmission
- System for case detection & proper management of post kala-azar dermal leishmaniasis (PKDL)
- Regular insecticidal spray rounds supplemented with focal spray around new cases as per national guideline
- Reduce incidence of malaria and finally eliminate it form the state active and passive surveillance, vector control measures, prompt action to outbreak and awareness generation

9.0 Habitat

Ensuring sustainable habitat for all is another objective of SAPCC. The plan for this sector is now required to be oriented with NDC of India and demands a detail review, which is beyond the scope of this report due to the time line of this project. However, to provide an idea about the most emphasized programmed in this sector i.e. solid waste management, a case study is described below.

Municipal solid waste generation in the state in estimated to be 14,000 TPD[125]. MSW is being generated from 125 urban local bodies as well as panchayats. 12,600 TPD, i.e. 90% of this MSW is collected, 830 TPD is treated in various compost plants, which are operational in 10 municipalities and 515 TPD is sent to sanitary land fills of 13 municipalities[126]. Compost plants in 11 additional municipalities and sanitary landfills in 12 municipalities have been set up, which shall reduce the gap between waste generation and proper disposal and treatment. Bio-methanation is also being attempted in different districts. The case study of Kalimpong district is described briefly in next section.

Biomethanation of Solidwaste Management – a case study at Kalimpong[127]

Kalimpong Municipality was facing major issues regarding their solid waste handling and management. Due to the tourist importance and the potential of the place, the population of the city was expanding and the authorities faced a challenge in coping up with the increasing population. Several rounds of meetings were conducted by the Kalimpong Municipality. Finally, a conclusion was made to bring up a Biogas Plant for the Project Area. EClean Spectron Environment Pvt. Ltd was selected as the entity responsible for the design, construction and implementation of the biogas plant.

The Biogas Plant has been set up at Chota Bhalukhop Range. The facility can accept 5 MT of Solid waste with 3 MT of that being organic waste daily. The end products for the facility are: Biogas and Organic Manure. It is an initiative taken by the Kalimpong Municipality to minimize the garbage related problems within the project area and make Kalimpong a cleaner town.

The Biogas Plant Facility is provided with an additional Waste Segregation Facility, the segregation is carried on manually by local workers on daily wage basis. The Biogas Plant is expected to radically improve the solid waste scenario of the project area. It is a zero discharge Solid Waste Management Facility and will create several revenue streams for the town in the near future.
The selected site was provided by the municipality based on twin concerns of availability and lack of objection by the adjacent residents. The site was located on a steep slope, close to the area that

[125] "Report on State Policy and Strategy on Solid Waste Management for Urban Areas of West Bengal prepared by U and MA Department.

[126] Annual Report West Bengal 2016-2017, WBPCB, page 70-72

[127] Communication from U&MA department

receives solid waste currently. The land development process involved preparing the land so that the biogas reactors can be placed on the platforms that can withstand earthquakes and landslides. This involved removal and anchoring to underlying rocks in the area.

Several teams of civil construction personnel were deployed for creating the foundation and access-way and platforms required for the facility. This included foundations for two aerobic digesters and one anaerobic digester along with the sorting platform, access chutes, stairs, mixing platform and sludge holding basin.

Due to lack of drivable roads to the project site, the entire fabrication work was done on-site from plates brought in from Kolkata and Siliguri. The entire fabrication team was placed at the site for the duration of the project. The piping and installation team connected the different equipment at the site to make the process functional.

A trial run was performed by starting the plant with cow-dung to get the microbial culture initiated and gradually increased feed of the solid waste into the plant. Gas started generating after 2 weeks and the process has been continuously generating gas since then.

Currently, the solid waste is being sorted at the adjacent platform and the biodegradable waste is being fed into the biogas facility to generate gas. The municipality is collecting the biogas in truck mounted steel tanks steel tanks for transportation to the schools for its school lunch program.

AT present, biogas is going to two schools for cooking application. A third bullet was also provided to the municipality to serve any other potential user of the gas. The second byproduct; the organic fertilizer is being planned to be utilized for the horticulture plantations that are common for Kalimpong.

All the stages of the project were started in 2014 and completed in 2016. The facility processes approximately 5 MT of Solid wastes, with 3 MT passing through the biogas plant. It is projected that approximately 90 kg of biogas and 180 KG of organic fertilizer is being generated per day

10.0 Generation of Knowledge to Combat Climate Change

10.1 Actions taken at Department of Environment, Government of West Bengal

The Department of Environment (DoE) is the nodal department for climate change activities in the state. The Environment Department has spearheaded the preparation of SAPCC 2012 and 2017. The Department is facilitating line departments to mainstream the climate change perspectives. The following projects have been facilitated in 2015-16:

- A project has been prepared on Vulnerability Assessment of Darjiling Himalayas under the National Mission for Sustaining Himalayan Ecosystems (NMHSE) in collaboration with the **Department of Science and Technology.** The project has been sanctioned by the Ministry of Science and Technology. At present work is going on.
- Work has been initiated for water sector specific action plan under the National Water Mission (NMW). A nodal cell has been set up in the **Irrigation and Waterways Department** involving other departments, for implementation of climate change related plans in the water sector. At present work is going on.
- A project has been prepared for mass scale decentralized roof top rainwater harvesting in poorer households within Darjiling Municipality. The project has been sanctioned by the Ministry of Environment Forest and Climate Change, Government of India under the National Adaptation Fund Climate Change (NAFCC). At present work is going on.

The Department of Environment has played key roles in ensuring the successful completion of a demonstration project on 'Livelihood Diversification' through Integrated Production Systems at different locations of Maldah and Murshidabad districts, jointly by Development Research Communication & Service Centre (DRCSC). This project was supported and facilitated by GIZ and MoEF&CC under CCARI (Climate Change Adaptation in Rural India). The Department of Environment, GOWB was the state partner for this project.

In fact, the success of this demonstration project catapulted to awarding of the first project under **Adaptation Fund** to any Indian agency. US$ 2.5 million (approximately Rs. 15 Crores) Adaptation Fund has been awarded to The Development Research Communication & Service Centre (DRCSC) for the project on "Enhancing Adaptive Capacity and Increasing Resilience of Small & Marginal Farmers of Puruliya and Bankura Districts, West Bengal".

DoE has entrusted TERI for Vulnerability studies of coastal districts of West Bengal. The report on coastal districts is at the draft final stage. The Department has taken up two projects on climate modelling for providing useful inputs to executing departments.

- **District wise (0.25^0x0.25^0) Statistical Downscaling of Global Circulation Model (GCM) by IIT Bombay**

The first project has been completed. The objective was to obtain season wise and district wise climate projections at 10 year interval by downscaling the output of global circulation models. Summary results has been discussed in Chapter 3.2.

- **Extended weather forecasting for West Bengal**

The objective of the second project is to obtain "Extended Weather Forecasting (EWF)" for West Bengal.

The same is being continued at the National Level. The Conventional forecasting is augmented by output of climate change models for EWF.

10.2 Proposed Action and Targets

Setting up a Climate Service Centre at the Department of Environment, West Bengal

The line departments are busy in executing their mandated duties and it is not always easy for them to find time to go through and understand the scientific dialogues communicated by the hard core climate scientists and hydrologists. The climate service centre shall act as an interpretation centre or linking node between the end user departments and climate research institutes.

The objective of the state climate service centre shall be:

- To obtain updates on climate change from reputed scientific research organizations
- To translate/ interpret climate change science , to transfer knowledge to the stakeholder departments/ to the end users and also
- To obtain the feedback and communicating the same to the scientific community for further development in a consolidated manner

B. Mitigation Approaches of West Bengal

The State of West Bengal is also taking part in the world wide drive for GHG mitigation. Actions taken/ being initiated in two major contributors Power and Transport are discussed in the following two chapters.

11.0 Power Sector

11.1 Background

In West Bengal, there are three electricity generating agencies - state level, central and private sector agencies. The various agencies are given in Table 11.1 below.

Table 11.1: Power Generation Agencies in West Bengal

Power Generation Agencies		**Type of power generated**
State Sector		
1	West Bengal Power Development Corporation Limited (WBPDCL)	Thermal
2	Durgapur Projects Limited (DPL)	Thermal
3	West Bengal State Electricity Distribution Company Limited (WBSEDCL)	Thermal
4	West Bengal Renewable Energy Development Agency (WBREDA)	Hydel and nonconventional energy generation
Central Agencies		
1	Damodar Valley Corporation (DVC)	Thermal and hydel power
2	National Thermal Power Corporation (NTPC)	Thermal
3	National Hydroelectric Power Corporation (NHPC)	Hydel Power
Private Sector Agencies		
1	CESC Limited	Thermal
2	India Power Corporation Limited (IPCL)	Thermal
3	Haldia Energy Limited (HEL)	Thermal

Source: Economic Review West Bengal, 2015

11.2 Installed Capacity

The total installed capacity of the power stations in the state during the last 5 years is shown in Table

11.2 below. Between 2011-12 and 2015-16, the installed capacity and energy generation have increased by about 50%, thereby addressing the electricity shortage issues of the state. It has substantially helped increase in household and rural electrification as well as reduction in power cuts.

Table 11.2: Installed Capacity of Power Generation in West Bengal

At the end of the year	Installed Capacity (MW)	Energy Generation (MU)
2011-12	10338.33	47960.65
2012-13	12667.75	63866.16
2013-14	12769	65655.2
2014-15	13479.57	66149.35
2015-16	15804.57	NA

Source: Installed Capacity figures – Economic Review
Energy Generation – Statistical Handbook, 2015

11.3 Household and Village electrification in West Bengal

The household and village electrification in the eighteen districts of the state improved substantially during 1990 to 2015. During this period, the total household electrification increased about 16 times from 732,866 to 11,635,010. Districts like Jalpaiguri and Uttar Dinajpur experienced the highest growth where the increase is about 25 times, followed by Murshidabad and Birbhum, where the rise has been about 20 times. In this time period, the village electrification increased about 1.5 times, from 24,582 to 37,959 villages. (Source – Statistical Handbook 2015).

11.4 Agency-wise Installed Power Generation Capacity

The installed thermal power generation capacity in West Bengal in 2015-16 by different agencies is given below in Table 11.3 and Table 11.4.

Table 11.3: Installed thermal power generation capacity West Bengal (MW)

Agency (Public/ Private)	Year 2015-16				
	Thermal	Hydro	Pump Storage	Others	Total
WBPDCL	4865	NA	NA	NA	4865
DPL	660	NA	NA	NA	660
WBSEDCL	NA	176.55	900	0.82	1077.37

Agency (Public/ Private)	Year 2015-16				
	Thermal	Hydro	Pump Storage	Others	Total
WBREDA					
DVC (WB Unit)	4890	63.2	0	0	4953.2
NTPC (WB Unit)(Farakka – 2100 MW, Durgapur (JV of NTPC) - 120 MW	2220	NA	NA	NA	2220
NHPC (WB Unit)	NA	292	NA	NA	292
CESC	1125	NA	NA	NA	1125
IPCL	12	NA	NA	NA	12
HEL	600	NA	NA	NA	600
Total Installed Capacity	14372	531.75	900	0.82	15804.57

Source: Economic Review 2015

In addition to above, the following Electricity Generation Capacity has been set up in West Bengal in 2016.

Table 11.4: Additional Electricity Generation Capacity

Agency	**Capacity (MW)**
Cresent	40
PCBL	30
33 KV Captive & IPP (approximate)	140
WBGEDCL (Solar)	2
Hindustan Power (Solar)	5
WBSEDCL (Solar)	10

Source: Department of Power, West Bengal

11.5 Share of different energy sources

Table 4 indicates the electricity generation from different sources. Thermal power continues to constitute the highest share. Following various thrusts from government, as seen from the table, solar PV generation commenced in the state from 2012-13 onwards, however, as per the statistics, it reduced in the subsequent years.

Table 11.4: Source wise electricity generation

Type	Energy Generated (MU)	2010-11	2011-12	2012-13	2013-14	2014-15
Steam (Thermal)	"	54232.91	57060.32	62510.96	64222.61	64079.48
Oil (Diesel)	"	0.88	0.47	-	-	-
Wind	"	-	-	0.29	0.47	-
Hydro (Hydel)	"	410.27	549.45	555.87	646.68	653.25
Gas	"	-	-	-	-	-
Solar PV	"	N.A.	N.A.	1.54	0.73	0.56
Pump Storage	"	878.88	766.41	797.5	784.71	1416.06
Total	"	55522.94	58376.65	63866.16	65655.2	66149.35

Source: Statistical Handbook 2015

11.6 Sector wise Consumption of electricity

Table 11.5 indicates the trend of electricity consumption by different sectors during 2010-11 to 2014-15. As indicated in the table, the share of domestic consumption has increased during this period from 16.45% to 18.54% and that of industries reduced from 27.98% to 25.15%. The share of electricity consumption by all other sectors have remained more or less constant.

Table11.5: Sector wise Electricity Consumption

	2010-11	2011-12	2012-13	2013-14	2014-15
Total energy sold* (MU)	53990.95	58374.89	66200.77	64580.71	68291.74
Within the State	Percentage of each category to total sale				
Sectors					
(a) Domestic or Residential	16.45	16.6	16.73	17.45	18.54
(b) Commercial	7.7	7.59	7.36	7.69	7.87
(c) Industrial	27.98	27.89	25.91	26.72	25.15
(d) Public Lighting	0.63	0.66	0.62	0.94	0.6
(e) Railways / Tramways	2.22	2.15	1.99	1.76	2.1
(f) Agriculture (Irrigation or de-watering	3.34	2.22	1.88	1.83	2.18

	2010-11	2011-12	2012-13	2013-14	2014-15
(g) Public Water Works and Sewerage Pumping	1.03	1	0.92	1	1.03
(h) Miscellaneous	1.34	1.28	1.1	1.15	1.34
Outside the State	2.53	4.29	11.8	12.78	9.76

* Total of electricity consumption is not showing as 100 % as the distribution of consumption in different sectors under WBPDCL is not available.

Source: Statistical Handbook 2015

11.7 Projected Power Demand 2020-21 & 2030-31

A Perspective Plan of West Bengal Power Sector 2006-30 was prepared in 2006 by the State Level Committee for Preparation of Perspective Plans for Power Sector set up by Government of West Bengal. Projections of electricity demand for the period 2020-21 to 2030-31 was carried out in the plan for two scenarios – 1) CAGR of 5.16% based on trend between 1999-2000 to 2004-05 and 2)10 year trend with adjustment. The projected energy demand is given in Table 11.6.

Table 11.6: Projection of Electricity Demand in West Bengal

Year	Energy Demand (MU)	
	Scenario 1	Scenario 2
2020-21	66368	71351
2021-22	69792	74161
2022-23	73393	76971
2023-24	77180	79781
2024-25	81163	82592
2025-26	85351	85402
2026-27	89755	88212
2027-28	94386	91023
2028-29	99257	93833
2029-30	104378	96643
2030-31	109764	99454

As per the above table, the energy demand for 2020-21 was projected to be 66,368 MU in scenario 1 and 71,351 MU in scenario 2. However, as given in Table 11.5, the energy demand in 2014-15 was 68,291.74 MU. Hence, it can be inferred that so far, the growth in energy demand in the state has been faster than that projected in Scenario 1.

11.8 Renewable Energy

As seen in Table 11.4, coal continues to constitute the highest share in energy generation in West Bengal thereby resulting in consequent increases in greenhouse gas emissions and climate change impacts. Formulation of mitigation options like renewable energy are therefore extremely crucial. Generation of electricity from renewable sources of energy will increase the share of green and clean power in to grid electricity thereby reducing dependency on fossil fuel. It will also meet the basic electricity needs in unelectrified areas.

Emphasis has been given to increase the share of renewable energy in the total energy mix of the state. There is an urgent need to expedite it along with exploring other sources of renewable energy.

11.9 Actions by West Bengal for mainstreaming mitigation programs in power sector to address climate change

Framing West Bengal Energy Conservation Building Code (WBECBC), 2016 - As per the policy on 'cogeneration and generation of electricity from renewable sources of energy', it is mandatory for all the public buildings to have solar devices to meet the electricity requirements and other applications. All existing and upcoming commercial and business establishments having more than 1.5 megawatt of contract demand are required to install solar rooftop system to meet at least 2% of the electrical load. Further, all the existing and upcoming schools, colleges, hospitals, large housing societies and government establishments having a total contract demand for more than 500 kilowatt will be required to install solar rooftop system to meet at least 1.5% of the total electrical load. In this respect WBSEDCL has already taken the initiative with relevant departments to modify the energy conservation building code.

WBECBC, 2016 has been published in the Kolkata Gazette on 22.3.2016 with the following application:

1. The code is applicable to buildings and/or building complex that have a connected load of 100 kilowatt or greater or a contract demand of 120 KVA or greater
2. The provisions of this code apply to:
    - building envelope except for air- conditioned storage spaces or warehouses
    - Mechanical systems and equipment including heating ventilating and air conditioning
    - service hot water heating
    - interior and exterior lighting and
    - electrical power and motors

3. The provisions of this code do not apply to:
   - (a) buildings that use r electricity or fossil fuel
   - (b) equipments and potions a building systems that use energy primarily for manufacturing processes

For implementation of WBECBC, an ECBC cell is being constituted in WBSEDCL with representatives from power and NES, Municipal Affairs, Urban Development, Panchayat and Rural Development and PWD departments. The cell will look into the aspects of inclusion of ECBC provisions in the concerned bye laws of municipal bodies/ departments, training, awareness building etc.

11.10 Following RE initiatives have been undertaken in the state since 2012

Roof top based solar power plants of total 26.47MW capacity has been installed in different parts of West Bengal. The details are provided below:

- Installation of 10 numbers 2 kW off-grid solar PV power plants in schools, Grid connected Rooftop Solar PV Power Plant at 75 numbers of 5 kW (with net metering) and 15 numbers 10 kW grid connected (with net metering) in PHC's throughout West Bengal. The project is funded by WBPCB, Department of Environment, Government of West Bengal.
- Renovation of 2 MW grid connected PV power plant at Jamuria, Asansol with financial assistance from Department of Electronics and Information Technology Government of India through National Mission on Power Electronics Technology
- Installation of 15 kW grid connected rooftop Solar PV power plant (with net metering) at Maheshtala Municipality Building, Maheshtala, South 24 Parganas.
- Installation of 20 kW grid connected rooftop Solar PV Power Plant at NIBMG, Kalyani Nadia, North 24 Parganas.
- Initiative with DISCOM to keep records of the fulfillment of RPO target as provided in WBERC regulations.
- As Project Monitoring Consultant for 150 kW grid connected Rooftop SPV power plant at Haldia Dock Complex, Kolkata Port Trust
- As Project Monitoring Consultant for 160 kW Rooftop Grid Connected SPV power plant at Kolkata Dock System, Kolkata Port Trust.
- Installation of Rooftop SPV power plants in 100 schools/ PHC's throughout West Bengal with financial support from WBPCB
- Grid connected Rooftop Solar PV Power System at 500 schools (200 schools under WBSEDCL, 200 schools under WBREDA and 100 schools under WBGEDCL) is under implementation
- Another similar project (Grid connected Rooftop Solar PV Power System) for 1000 schools each of 10 kilowatt has been taken up by WBREDA
- WBREDA and DPL have jointly signed an agreement for setting up a 500 kW Grid Connected

Solar PV Technology demonstration power plant. Will be done in two phases (200 kW + 300 kW). DPL and WBREDA are the joint owner of the proposed SPV Power Plant. The project is approved by the government (both State and Central)

- Alo shree - State Government has launched an ambitious program of rooftop solar systems name Alo shree program. The objectives of this program is to install Grid Connected Solar Photovoltaic System in all government buildings and buildings of local bodies by 2017-18. The target is to install 60 MW and 120 MW by 2016-17 and 2017-18 respectively with a financial involvement of Rs 1,260 crore.
- First phase tendering for Alo Shree is underway. WBREDA is in discussion with MNRE, Government of India, for obtaining Central financial assistance under National Solar Mission.
- Grid connected solar rooftop PV program under integrated power development schemes (IPDS) - Under IPDS, WBPDCL is going to install 5 megawatt Power Solar roof-top plants in urban areas of the state in the first phase.
- Solar Canal Bank Project - A 10 MW solar project has been installed and inaugurated in August 2016 on the Teesta river canal bank in Uttar Dinajpur district with a project cost of Rs 69.74 crores. Financial assistance was received from MNRE and NABARD. The state government is also planning to set up another 10 megawatt Solar Canal Bank project in 2017-18.
- Solar Park - The state government has taken an initiative of facilitating investment opportunity by way of establishing Solar Park equipped with necessary infrastructure for installing total 500 megawatt power. Of this, 200 megawatt capacity has been planned to be set up in the first phase at Dadanpatrabar in East Medinipur. In principle clearance for setting up 500 megawatt solar Park has been obtained from the Government of India.

Apart from above, following two activities also generating solar power:

Installation of grid connected pole top solar street lighting

- Urban Local Bodies (ULBs) like Kolkata Municipal Corporation (KMC) are implementing roof top solar projects. Kolkata Municipal Corporation has installed pole top solar lightings in select areas for grid connected carbon neutral lighting.

Remote village electrification by solar power

- Different villages under Sagar and Gosaba block have been/are being provided with solar Home lighting and solar street lighting systems.
- Large scale solar power project - Feasibility of some innovative and large scale solar power projects like connecting a solar photovoltaic power plant to the proposed 1,000 MW Turga pumped storage project in the Ayudha Hills in Puruliya district is being examined. Pumped Storage Projects store energy in water and thereby act as a kind of giant battery. A Pumped Storage Project of 900 MW capacity has been successfully working in Bagmundi since 2007.

  In the Turga project, the plan is to setup of phase-wise 1,200 megawatt solar photovoltaic power plant to supplement the pumping power requirement. This will entail all the electricity

generation from the Turga Pump Power Storage project from renewable sources and it will be the first of its kind in the world. The total cost for setting up of the solar power project is Rs 7,800 crores. This is in addition to the estimated Rs 4,200 crores cost for the construction of Turga Pumped Storage Facility for which sanction has recently been obtained from the Government of India. One thousand acres of land in East Medinipur district for the first 250 megawatt phase of the project is available. An additional 1,350 acres of land has been identified in Paschim Medinipur, Puruliya and Bankura for the second phase of the project

12.0 Transport Sector

West Bengal is well connected by road, rail, and air routes to other major cities of India. Bus services in the state are operated by various government owned organizations as well as private bus companies. The railway system in the state is also an important mode of transport which connects the state to other major places of India. In cities, cars, 2-wheelers, taxis and cycles are the main personal modes and amongst IPTs, auto rickshaws (3-wheelers) and battery operated totos are very popular. Hand-pulled rickshaws are also used in cities and towns for short distance traveling. Several rivers flow in the southern part of the state hence ferry is a principle mode of transport there - especially in the Sundarbans area this mode of transport is very popular. Trams are in operation in the capital city, Kolkata.

Overall, the transport department is responsible for the provision of transport facilities and infrastructure on road, inland water and air. It also provides administrative and legal Framework for the same.

12.1 Roads

In West Bengal, the Public Works Department and Public Works (Roads) Departments are mainly responsible for construction and maintenance of the roads. Some percentage of roads are also maintained by Municipalities and Zilla Parishads. The road length in the state over the years is presented in Table 12.1 below.

Table 12.1: Roads in West Bengal

Year	Estimated Length of Roads Maintained by Public Works and Public Works Departments	Estimated Districtwise Length of Roads Maintained by Zilla Parishads, Panchayat Samities & Gram Panchayats in West Bengal	Length of Roads Maintained by Municipalities and Municipal Corporations in West Bengal	Length (km)
2007	18,345	150,210.68 (2006-07)	24,544.05	193,099.73
2010	18,606	164,809.5	26,266.84	209,682.34
2015	17,525 (excluding water	180,920.15 (2012-13)	31,711.88	247,157.03

Year	Estimated Length of Roads Maintained by Public Works and Public Works Departments	Estimated Districtwise Length of Roads Maintained by Zilla Parishads, Panchayat Samities & Gram Panchayats in West Bengal	Length of Roads Maintained by Municipalities and Municipal Corporations in West Bengal	Length (km)
	bound macadum and unsurfaced roads)			

Source: Statistical Abstract 2015

12.2 Registered number of vehicles

Estimated Number of Motor Vehicles (Registered) on roads in West Bengal (as on 31st March) are presented below. It is found from the above two tables that the number of vehicles has increased at a much faster rate compared to the road length. Vehicles increased by 80% whereas the road length increased by only about 30%. This has led to consequent increase in energy consumption and GHG emissions. Also, the share of private modes of vehicles has grown much more in the last decade thereby leading to congestion, air pollution and GHG emissions, especially in the cities.

12.2 Number of Vehicles

Table 12.2: Number of Registered Vehicles in West Bengal

Year	Motor Car / Jeeps	Motor Cycle / Scooter etc	Taxi Contract Carriage/ Luxury Taxi	Luxury Taxi	Stage Carriage	Auto Rickshaw	Goods Vehicles	Tractor/ Trailers	Others	Total
2007	602,420	2,081,355	72,702	8,051	34,686	42,195	256,072	63,430	37,391	3,198,302
2011	537,866	2,607,055	72,352	7,336	32,854	62,579	285,733	77,024	25,081	3,707,880
2015	804,801	4,226,550	111,674	9,479	32,784	71,666	377,636	109,127	34,848	5,778,565

Source: Transport Department, Govt. of West Bengal.

Note: Figures relate to vehicles for which road tax was paid. Also, it appears that in 2009 and 2010, number of vehicles on road has reduced due to removal of vehicles aged more than 15 years as per Court order

12.3 Buses

The State Government nationalised the bus services of Kolkata in 1948 and converted it into a Corporation in 1960. North Bengal State Transport Corporation was also formed in 1960. The South Bengal State Transport Corporation, responsible for running buses in Durgapur and some other places in

South Bengal, was established in 1963. In 1989, another transport undertaking viz., West Bengal Surface Transport Corporation has been established, which deals with buses and ferry services.

Organisational restructuring (Integration of State Transport Undertakings) in Kolkata - Common Board of Management for Kolkata based STUs (CSTC, CTC and WBSTC) has been created recently which is known as West Bengal Transport Corporation (WBTC). State Transport Undertakings with technical assistance by the World Bank the STUs are going smart with electronic vending machines etc. More electronic dissemination is likely to be affected in a short time frame with the introduction of smart card, mobile app and passenger information boards.

Activities of the four State Transport Corporations are presented below in Table 12.3.

Table 12.3: Activities of four State Transport Corporations

Particulars	**1980-81**	**1990-91**	**2000-01**	**2010-11**	**2014-15**
Calcutta State Transport Corporation					
No of Vehicles on road everyday					
a) City	632	633	553	390	398
b) Long distance	106	210	268	111	3
Passengers served ('000)	298900	307641	307641	134320	61633
North Bengal State Transport Corporation					
Average number of buses put on road per day					
(a) Within the State	245	646	467	458	542
(b) Inter State	29	48	80	10	10
Total passengers served during the year (in lakh)	548	727	803.32	575.45	764
South Bengal State Transport Corporation					
Average number of buses put on road per day	82	235	328	350	393
Calcutta Tramways Company Limited (Bus Services started from November 1992)					
Average number of buses put on road per day	-		224	221	192
Total passenger served during the year (in lakh)	-	-	477	520	425
West Bengal Surface Transport Corporation Limited					
Average number of buses put on road per day	-	63	77	81.32	141
Total passengers served during the year (in lakh)	-	46	66	102.68	115.94

Source: Statistical Abstract 2015, GoWB

It appears that number of vehicles on road has reduced due to removal of vehicles aged more than 15 years as per Court order

12.4 Railways

The State is served by three zonal railways, viz., Eastern, South-Eastern, North-East Frontier Railways and Metro Railway in Kolkata. As seen in the table below, there has been about 10% increase in length of all the routes.

Table 12.4: Railway Route in West Bengal Open for Traffic (As on 31st March)

(in km)

Year	**2008**	**2010**	**2012**	**2015**
Eastern Railway	2413.83	2413.82	2447	2665.9
North East Frontier Railway	1049.99	975.51	1009.51	1009.51
South Eastern Railway	1081.66	1075.61	2136	1125.96
Total	4545.48	4464.94	5592.51	4801.37

12.5 Shipping

Foreign and coastal shipping handled by Kolkata Port and Haldia Ports have more than doubled since 1990-91. The major import products include coking and non coking oil, petroleum products, limestone, manganese etc. Export items include thermal coal, fly ash, iron & steel. As seen below, the import traffic is about three times more than the export traffic.

Table 12.5: Traffic handling at Kolkata Port

	(in thousand tonnes)	
	1990-91	2014-15
Total Import Traffic Handled in terms of Principal Commodities at Kolkata Port - Kolkata Port (Combined figures for Kolkata and Haldia)	10606	36248
Import Traffic Handled at Kolkata Port	3162	9816
Import Traffic Handled at Haldia Dock	7444	26432
Total Export Traffic Handled in terms of Principal Commodities at Kolkata Port - Kolkata Port (Combined figures for Kolkata and Haldia docks)	4634	10045
Export Traffic Handled at Kolkata Dock	964	5467
Export Traffic Handled at Haldia Dock	3670	4578

12.6 Kolkata Metro

Kolkata is the first city in India to operate metro. On 24th October 1984, the first stretch of about 3.4 km between Esplanade and Bhowanipur was completed, and started operations soon after that. Over the years, others stretches on the corridor were gradually completed and some extensions were also made. The network currently consists of one operational line of 27.22 km from Noapara to Kavi Subhash with five other lines in various phases of construction. It carries more than five lakh passengers a day today[128].

Kolkata metro has 24 stations, 15 of which are underground, 7 are elevated and 2 stations are at grade. The average length between any two stations is 1.14 km. The shortest distance is 0.597 km between Central and Chandni Chowk, whereas the longest distance is 2.15 km between Dum Dum and Belgachia. Since the electrification of Kolkata metro is of the 3rd Rail, 750 V DC, electricity substations were built in Jatin Das Park, Central, Shyambazar129. The type of tracks are ballast-less with M1A track fittings.

Signalling and frequency

Kolkata metro trains operate on typical Indian Railways automatic signalling technology. A Route Relay Interlocking System has been provided at Mahanayak Uttam Kumar and Noapara carshed and are in operation to facilitate the prompt withdrawal and injection of rakes as well as performing shunting operations inside the car shed, required for maintenance purposes. Train Protection & Warning System (TPWS) is provided on the entire stretch of the Metro Railway. This system is designed to prevent collision caused by human (operator) error[130]. Train Describer System and Auto Train Charting have also been provided to help the operation control centre to monitor and plan train movement on a real time basis[131].

The Metro Railway operates between 06:45 and 21:55 hours, running every 7 minutes and every 5 minutes during peak hours on weekdays. Metro runs on Sundays between the hours of 09:50 to 21:55 hours. A number of 270 trains run everyday during week days, 205 on Saturdays and 92 on Sundays.

Tokens

After using the magnetic ticketing system for 27 years from 1984 to 2011, Kolkata Metro introduced Radio-Frequency Identification (RFID) tokens by Centre for Railway Information Systems (CRIS) from 2011. The old magnetic strip reader gates were replaced by new RFID readers.

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[128] http://kmrc.in/overview.php

[129] http://www.mtp.indianrailways.gov.in/view_section.jsp?lang=0&id=0,1,304,375,376

[130] https://timesofindia.indiatimes.com/city/kolkata/Automatic-warning-to-make-Metro-safer/articleshow/18771909.cms?referral=PM

[131] http://www.mtp.indianrailways.gov.in/view_section.jsp?lang=0&id=0,1,304,394,407

Smart card

After introducing RFID tokens, Kolkata metro introduced a Smart Card service introduced by Centre for Railway Information Systems (CRIS). These smart cards are multi-programmable and commuters can opt for the various multi-ride schemes. The general smart card is most popular among daily commuters to avoid the queue.

Security

All stations are equipped with closed-circuit cameras and metal detectors, making the metro the safest form of transport in Kolkata132. Taking photographs and smoking are strictly prohibited in the metro premises.

In 2010, the Railway Ministry announced plans for the construction of five new metro lines and an extension of the existing North-South corridor. These new projects are:

- Salt Lake City - Haora Maidan (East-West Metro Corridor)
- Joka - BBD Bagh
- Noapara - Barasat via Biman Bandar (Airport)
- Baranagar - Barrackpore
- Noapara - Dakshineswar
- New Garia - Biman Bandar (Airport)

The 'East West Metro Project' is a unique Metro rail project where twin underground tunnels have passed below the mighty River Hooghly. This is the first such ambitious attempt in the country. The unique challenges posed by Kolkata's soft ground condition and densely populated urban environment are being addressed by choice of Earth Pressure Balancing Tunnel Boring Machines and well engineered tunnelling operations.

The Project is being executed in two phases - Phase-I from Salt Lake Sector V to Phoolbagan and Phase-II from Phoolbagan to Haora Maidan. Phase-I (7.27 km) is targeted for commissioning by June 2018 and Phase-II (9.28 km) by December 2020.

Tunnelling below River Hooghly

All preparations for crossing of the 520 metre long River Hooghly have been made. Tunnelling below the river started in April 2017 and has been successfully completed in 66 days which is a remarkable success. This is the 1st transportation tunnel of the country under any mighty river.

Environmental issues

[132] http://www.dnaindia.com/india/report-kolkata-metro-to-install-x-ray-baggage-scanners-1749283

A project of the size of 'East-West Metro' passing through the most densely populated areas of Kolkata is a huge environmental challenge. Both the original Project as well as modified proposal have been cleared by West Bengal Pollution Control Board as well as Environment Department of GoWB. The Company is strictly implementing the Environmental Management Plan as indicated in the EIA report. The 'East-West Metro' Project values preservation of the environment and minimising adverse impact on the greenery. About 1,335 trees had to be removed for execution of the Project against which 6,900 trees have been planted at a total cost of Rs. 45.61 lakh[133].

Conservation of energy

The Company has initiated various energy conservation measures to ensure optimal use and also selecting appropriate technology for various systems. The detailed measures are as under:

(i) steps taken for conservation of energy:

- LED-type lighting in the stations and train coaches.
- Provision of Platform Screen Doors in underground stations, which would reduce air conditioning requirement substantially and thereby reduce consumption of non-traction energy.
- Rolling Stock planned to be procured for the Project envisages regenerative braking - so that power is generated at the time of braking, which would be consumed by other powering trains running in the system.
- Elevated station architecture kept in such a way to use natural lights in day time to the extent possible.
- Use of polycarbonate sheets on elevated stations has been given a fillip to reduce carbon footprint.
- High COP-type air-conditioning units have been envisaged for underground stations along with energy management system so as to optimise use of chillers, cooling towers, pumps, etc.

(ii) steps taken for utilising alternate sources of energy:

- Large banks of solar cells shall be provided at the Maintenance Depot to generate energy for internal consumption.
- Depot layout has been kept in such a way so as to use natural lights to the extent possible.

Constructions on the other lines have commenced and ongoing.

Kolkata Metro snapshot

Kolkata Metro

Stations	Length (km)	Ridership (millions)

[133] http://kmrc.in/admin/uploads/KMRCL_Eng_Hindi.pdf

	24	28	237
	Ranking		
India	4	4	2
Asia	53	59	27
World	112	113	53

The ridership of Kolkata metro is expected to increase substantially after the above mentioned corridors are completed and operational.

12.7 Transportation in major cities

Kolkata, the capital city of West Bengal, is an unique city having several modes of traffic other than road and rail. It is the only city of the country having trams as a mode of transport. Trams are operated by the Calcutta Tramways Company. Due to several challenges, the tram operation has declined over the years, however, it is an energy efficient environment friendly mode of transport and there is great potential in reviving this heritage.

Table 12.6: Trams in Kolkata

Particulars	**1990-91**	**2000-01**	**2010-11**	**2014-15**
Number of tram cars	396	319	269	269
Total route length (in km double track)	71	68	131	119
Average number of vehicles put on road per day	253	164	95	93
Total passenger served (in lakh)	1826	596	490	305

Kolkata was the first city in India that introduced public transportation system running on electricity, way back in 1985-86, the Kolkata Metro. In addition to the metro, which is running underground, there is also an at grade Circular Rail system running across Kolkata. The length of the metro network increased from 16.4km to 27.28 km during 2008-2015. The ferry/ launch service on Ganges is very popular connecting the city with Haora and other towns.

Table 12.7: Launch Services by West Bengal Surface Transport Corporation Limited

Particulars	2000-01	2010-11	2014-15
Fleet strength as on 31st March (number)	23	41	46

Total length run during the year (in km.)	153957	-	41200
Average number of launch vehicles put on river per day	18	17	21
Total earnings (Rs. in lakh)	322.01	588.45	1140.85
Total expenditure (Rs. In lakh)	543.85	582.83	1071.74

Source: Statistical Abstract 2015

There are many other large and medium size cities and towns in West Bengal which include Durgapur, Assansol, Jalpaiguri, Kalyani, Krishnannagar, Burdwan etc, however, the transportation issues due to scarcity of road space, scale, volume, congestion, diversity, mileage, safety etc, and, the consequent GHG emissions are highest in Kolkata. Vehicular air pollution is a growing problem in Kolkata due to increased travel demand and high growth of motorized vehicles. The number of registered vehicles corresponds to more than 50% growth since the last decade with less than 7% of effective road space leading to high automobile density, disproportionately low percentage of road network, congestion, accidents and effect on air quality[134].

The annual average concentration of Respirable fraction of Particulate Matter (PM10) for the past two years in Kolkata are 119.8 microgram/Nm3 (2015) and 124.9 microgram/Nm^3 (2016) respectively, which is almost double the NAAQ (National Ambient Air Quality) standard of 60 microgram/Nm^3. In the past two years, the annual average concentration of NO_2 has also exceeded the permissible NAAQ standard of 40 microgram/ Nm^3. Increase of NO_x is directly linked to increase in fuel emission and can be attributed to the increase in vehicular emission in the city.

12.8 GHG emissions from the transport sector

Most of the vehicles in the state are driven by fossil fuels and are constant sources of air pollution and GHG emissions. The CO_2 emission assuming typical kilometre run, fuel use etc. from the transport sector in West Bengal is estimated to be about 12,000 Gg/year.

In order to address the congestion and pollution issues in the cities and towns, it is time to consider alternate options like introducing alternate energy efficient environment friendly fuels and technologies, increased use of mass transport to reduce fuel consumption, and increased traffic management to reduce congestion and a smooth flow of traffic. Improved mileage and other low carbon alternatives can enhance mobility without increasing GHG to the atmosphere.

134 http://www.thesij.com/papers/ASREE/2013/September-October/ASREE-0102520401.pdf

12.9 Alternate fuel & technology options in Transport Sector

12.9.1 Electric Vehicles

Environment friendly energy efficient technologies such as electric vehicles (EV) present a technology-ready, viable and cleaner way to reduce GHG emissions and offer huge potential for fuel savings from the transport sector. They offer substantial environmental benefits and emissions in case of EVs is nearly zero. EVs can be charged either through solar power, or, at night during off-peak hours, when electricity demand is the lowest. A feasibility study has been undertaken on promotion of electric buses in Kolkata in 2017, in which the favourable routes for introducing electric buses were determined and the cost implications were carried out. Following parameters suggested for selecting potential EV bus routes in Kolkata:

- Congested Routes - regenerative braking systems lead to improved performances with 'stop and go' condition
- Trip length – routes having an optimum trip length of about 80-100 kms are chosen to remain within the optimum range of 100-150 km run per recharge. Also, cost of buses increase with higher capacity batteries offering higher range
- Roof top space in Bus Depots – availability of adequate roof top area for installing solar panels for charging

Electric buses were found feasible in Kolkata and the payback period was 5-9 years. Applicability of FAME (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India) subsidy is also envisaged for the same. The scheme is coordinated by Department of Heavy Industry (DHI), Government of India. With FAME subsidy, the analysis showed that the payback period was about 3-6 years.

Following the above study, WBTC, Dept of Environment and Dept of Finance agreed to procure 20 electric buses in Kolkata in September 2017. In October 2017, DHI had invited Expression of Interest (EoI) for participation in incentive scheme under FAME-India Scheme for introduction of electric vehicles from West Bengal.

In October 2017, DHI invited Indian States including West Bengal for participation in FAME incentive scheme for procuring electric vehicles in million plus cities in the respective states. West Bengal Transport Corporation submitted application for subsidy for procuring 100 electric buses in Kolkata & 20 e-buses in Assansol in November 2017. In December 2017, DHI approved subsidy to WBTC for 40 electric buses and charging facilities in Kolkata.

WBTC decided to procure 40 AC electric buses (20 each of 9m & 12m) and charging facilities (15 slow charging and 5 fast charging stations). The tender was announced on January 29, 2018 followed by a prebid meeting that was attended by seven manufacturers. Possession of ARAI certification is

mandatory. Eight manufacturers participated in the bidding process, of which four of them technically qualified bidders for each of 9m &12m categories.

Financial bids were opened and the successful bidder was awarded the project. The first prototype will be ready in 4 months time (August – September 2018) for inspection by WBTC. After approval, 40 electric buses are to be supplied after 2 months. The total financial involvement is Rs 36.78 Crores of which Rs 21.50 Crores is the DHI subsidy and Rs 15.28 Crores will come from the State Plan Fund Grant.

Following the above tender, DHI offered in March, 2018, 60% subsidy to WBTC, for procuring another 40 electric buses. Due to paucity of time for conducting the tendering process, the same supplier has been asked for supplying 40 additional electric buses at the same rate.

12.9.2 E-ferries

Electric ferry, also known as E-ferry, is an electricity powered ferry system. Similar to electric cars, e-buses and e-rickshaws, this also contains a rechargeable battery system which is being charged in non-operation hours through other sources of electricity. Replacing fossil fuels and conventional diesel usage with pure electrically powered systems will increase the total energy efficiency substantially. Further, it will eliminate emissions if renewable energy sources are used for charging of the batteries. Additional renewable energy generation through installation of solar panels on the roof of vessels makes the e-ferries extremely environment friendly – this power can meet the energy demand of the ferries at night (lights, fans and other electricity requirements inside the vessel). The benefits of e-ferries will enhance further by generating the required electricity through solar power. A solar powered ferry comes with low operational costs and does not in any way pollute the water.

In West Bengal, a good network of ferries carrying both passenger and load carriage traffic (LCT – ferries that transport passenger and goods vehicles) run across the Hooghly river in and around Kolkata (Table 12.8). The service is managed and controlled by West Bengal Surface Transport Corporation (WBSTC).

Table 12.8: Ferry Services In Kolkata

SL No	Route	Fare (Rs)	Appx Distance (km)	Time Taken (mins)
1	Haora Station jetty - Shipping	5	1.5	7
2	Haora Station Jetty – Fairlie Place	5	1	5
3	Belur – Dakhineshwar	10	5 km	30
4	Bichalighat (Metiabruz) – Fairlie Place (via Haora, Ramkrishnapur)	20	5 km	40 – 45
5	Ariadaha – Fairlie Place (via Haora, Kutighat, Belur, Ratan Babur Ghat, Bagbazaar, Dakhineshwar)	20	10 km	1.5 hrs

SL No	Route	Fare (Rs)	Appx Distance (km)	Time Taken (mins)
6	Lot Number 8 - Kachuberia	8	6 km	45 mins – 1 hrs
7	Narayanpur – Namkhana	Varies for different type of vehicles	600m	10 mins
8	Hasnabad – Par Hasnabad	Varies for different type of vehicles	800m	15 mins
9	Nebukhali - Dulduli	Varies for different type of vehicles	0.8 km	15 mins

The total diesel consumption by the ferries operated by West Bengal Surface Transport Corporation in 2016-17 was about 800,000 litres[135]. These vessels, powered by diesel engines, cause air and water pollution. The noise, vibration, and diesel fumes also inconvenience the passengers. Average carbon dioxide emitted by ferries per passenger-kilometre is estimated to be 0.12 kg/pkm[136].

Considering the large amount of diesel consumption by the above ferries, oil spills and the consequent GHG emissions from the diesel powered ferries, introducing electric ferries will be an energy efficient climate friendly option. The benefits of e-ferries will enhance further by generating the required electricity through solar power. A solar powered ferry comes with low operational costs and does not in any way pollute the air and water.

Table 12.9: The details regarding WBSTC vessels are included below:

Parameters	2016-17	2017-18
New Vessel/ Load Carriage Traffic introduced	3	1
Fleet Strength WBSTC On lease to different municipalities	24	25 36 (may increase to 50)
Average no of out shedding	18	19
% of fleet utilization	75.00%	76.00%
Number of routes operated	9	9

135 Information received from WBSTC

136 Philippe Holthof, 'SO_X and CO_2 Emissions once again Hot Topic at Ferry Shipping Conference', *Ferry Shipping Conference 08: Building Bridges in the Industry*, accessed from http://www.shippax.se/backnet/ext/file/fileredirect.asp?id=229&file=bilaga_konferens_maj08.pdf 10 April 2009, p. 3.

Parameters	2016-17	2017-18
Number of new routes introduced	1	
Total traffic income/ revenue (lakhs)	7.57 crores	1.76 crores
Total non-traffic income/ revenue (lakhs)	2.44 crores	1.33 crores
Total operational expenditure – fuel consumption (MSD)	4.76 crores	1.19 crores
Total profit/loss	5.26 crores	7.04 crores
Staff strength including hired staff through agency)	289	287
Vehicle Staff Ratio	01:12.04	01:11.48
Number of depots/ units Namkhana Kachuberia/ Sagar Central traffic office (Millenium Park)	3	3

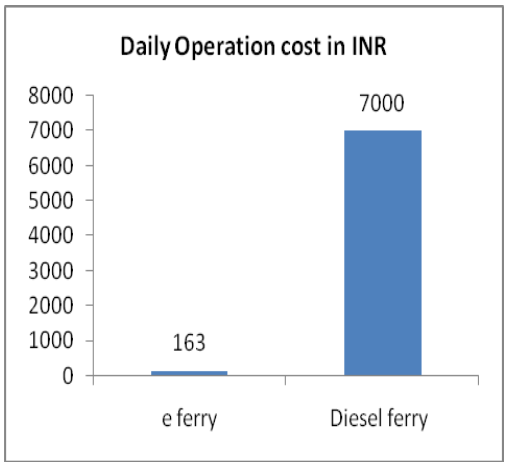
Table 12.10: Operational Details and Results for Details for Diesel Ferry

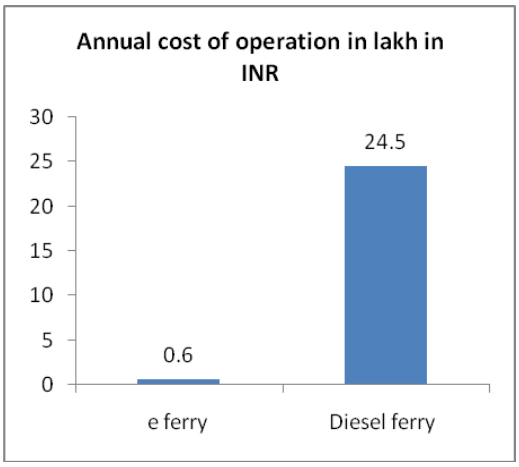
Days of Operation	Daily
Timings of Operation	7 am - 7 pm
Number of schedules trips	22 schedules
Daily cost of travel	Rs 163 (Rs 7,000 for diesel ferry)

OPEX

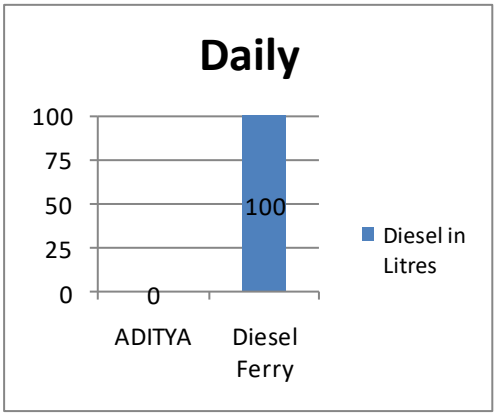
A comparative analysis of cost diesel consumption, CO_2 emission and cost operation suggests that e-ferry is an environment friendly, climate change friendly and economically viable option.

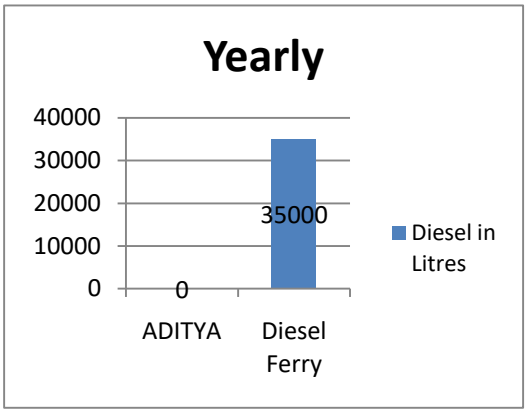
Cost Comparison





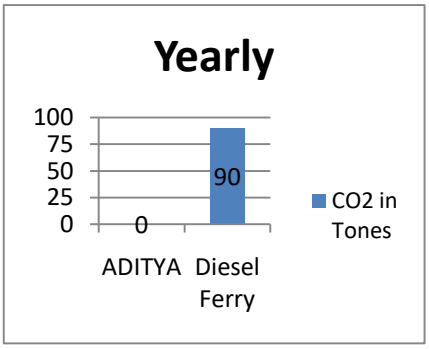
Comparison of fuel consumption (Aditya –an e-ferry and a diesel vehilcle)





Aditya has no Fuel onboard

CO_2 Emission



A solar powered ferry comes with low operational costs and does not in any way pollute the water. In addition to the vessels, operation of the bhutbhutis and the proposed mechanised boats by solar power will result in substantial savings in fuel and GHG emissions.

As per the details of ADITYA e-ferries, although the initial cost is slightly higher (20%), the yearly savings is about Rs 24 lakh – the payback of the additional investment cost therefore is little more than 2 years. The life of the e-ferries is about 20 years. Hence, even with the replacement of the batteries in the 7th and 14th year at around Rs 25 lakhs (at today's price, which is expected to reduce with increased adoption and demand of lithium ion batteries in electric vehicles), the savings from each solar ferry will be enough to buy another two solar ferries.

Inland water transport (IWT) represents a significant resource to the increasingly difficult challenge faced by the Indian transport sector, i.e. providing efficient and economic modes and mitigate congestion, traffic accidents and air pollution. Diversion of a part of the traffic from road to IWT will decongest the roads, reduce accidents and substantially reduce the transportation and fuel cost and environmental emissions12. The major benefits of IWT will enhance with replacement of diesel by electricity and further by electricity generated through solar power. A solar powered ferry comes with low operational costs and does not in any way pollute the water. Crossing the Hooghly river by ferries is generally faster and more convenient than by using clogged road and bridges (especially during the rush hours).

12.9.3 Studies Recommended

A study which will enable better policy making in respect of introduction of e-vehicles / hybrid vehicles / CNG vehicles / clean technology vehicles needs to be taken up urgently. The results of the study will enable précise transport planning to respond to the need for taking more mitigation measures for climate change.

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[i] Banerjee S., Das S., Mukherjee A., Mukherjee A., Saikia B "Adaptation strategies to combat climate change effect on rice and mustard in Eastern India", Mitigation Adaptation Strategies Global Change (2016) 21:249–261

[ii] http://envfor.nic.in/ccd-sapcc, State Action Plan on Climate Change West Bengal , Analysis of 37 years data