Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of West Bengal

ICAR- Indian Institute of Soil and Water Conservation
218, Kaulagarh Road, Dehradun-248 195

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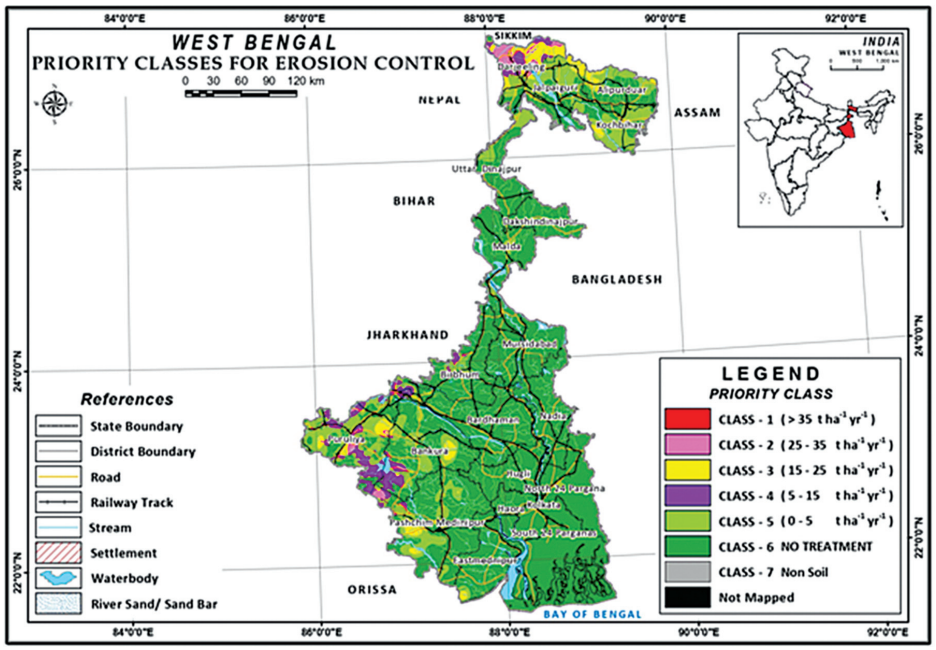

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14.03.2024

Foreword

I am delighted to know that ICAR-Indian Institute of Soil and Water Conservation, Dehradun alongside with its Research Centre, Koraput has prepared a technical document on "***Soil erosion status, priority treatment areas and conservation measures for different districts of West Bengal***" in accordance with the Institute's Research Advisory Committee's recommendations.

West Bengal is the fourth most populous state in the country with very diverse and rich natural resources. The geographical features of this state are typical unlike any other state, where it stretches from the Himalayas at the North to the Bay of Bengal in the south covering multifarious landforms in between. The state has a total area of 88,752 square kilometres. It is home to the world's largest delta, the Sunderbans which is a UNESCO heritage site.

The state has almost 70% of its population dependent on agrarian economy. This stresses the fact that management of natural resources and conservation of soil and water is indispensible for progress. Almost 19.5% of the total geographical area of the State is under desertification / land degradation for the period of 2011-13 which has increased by about 0.59% since 2003-05. Water erosion is most significant form of land degradation followed by vegetation degradation affecting all natural resources as well as the human recourses in the State. The impoverishment faced by the farming population due to severe climatic events like flood, cyclones, drought, coupled with land degradation requires step wise critical analysis of the situation, followed by solutions in a prescription mode.

This document focuses on the severity of soil erosion problems affecting various districts in the State. It includes the state's soil erosion risk map with separate priority classes and its extent, special degradation problems, soil and water conservation methods, in addition to the district-level agronomic, vegetative, and agroforestry measures. The information provided in this report is simple to comprehend and developed for use by different stakeholders across the state. I congratulate the team of ICAR-IISWC, Dehradun and its Research Centre Koraput, Odhisa for their sincere efforts in compiling and bringing this document in the issue of imperative importance.

(S.K. Chaudhari)

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PREFACE

The ICAR-Indian Institute of Soil and Water Conservation (IISWC), Dehradun is a national institute of Natural Resource Management (NRM) Division of the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture and Farmer's Welfare, Government of India. The Institute along with its eight research centres is continuously working for development of location specific, cost-effective soil and water conservation (SWC) technologies, imparting training to state government officials and developing model watersheds as a learning site for further adoption and up scaling in the field of soil and water conservation technologies and watershed management. The Research Centre (RC)-Koraput located in Odisha state is mandated to develop soil and water conservation technologies for Eastern India.

The background of development of this document on "Soil erosion status, priority treatment areas and conservation measures for different districts of West Bengal" lies in the deliberations and subsequent recommendation of the Regional Committee-VIII. The committee stressed on developing strategy for arresting soil erosion on priority for sustainable development of the southern region. On the recommendations and subsequent suggestions of the ADG (Agronomy, Agroforestry and Climate Change), a team comprising members from the Research Centre, Sunabeda was formulated at the Institute.

According to a report from the National Remote Sensing Agency in Hyderabad, West Bengal has experienced a desertification/land degradation rate of 19.54% of its total geographical area from 2011 to 2013. This marks an increase of 0.59% since 2003-05. The primary process driving desertification/land degradation in the state is water erosion, accounting for 14.98% of the affected area from 2011 to 2013 and 14.64% from 2003 to 2005. Following closely behind is vegetation degradation, comprising 2.99% of the affected area from 2011 to 2013 and 2.98% from 2003 to 2005.

As per the estimation of the ICAR-IISWC, Dehradun, there is an annual production loss of 4.00% alone in rainfed cereal, oil seed and pulse crops. Such degradation of land due to various forms of soil erosion leads to decrease in land productivity, and thereby economic loss propels risk to local food systems and livelihoods. The recently released IPCC's sixth assessment report predicts increase in heat waves, droughts, extreme rainfall events and likelihood of more cyclonic activity for India and the subcontinent over the coming decades. The annual precipitation is decreasing in large

areas of West Bengal, while the coastal areas are receiving increasing trends, which accelerate coastal erosion. The Sub-Himalayan region and the western parts of West Bengal are experiencing significant falling trend in monsoon season. Such a decreasing trend can enhance drought vulnerabilities, thereby degradation of forest and vegetation cover, which in turn enhance soil erosion. As Both positive and negative rainfall trend was reported for different parts of the state, which needs refined and redesigned regional coping strategies.

Considering the immediate need of various stakeholders for arresting soil erosion and averting land degradation, this document focus on identification of critical areas based on the permissible soil erosion rate and existing erosion rate at a given location in each district of the State West Bengal. The document contains soil erosion status and erosion induced losses including production and monitory losses at national level as well as for West Bengal. Besides, priority map, area under various degrees of risk and district specific agronomic, vegetative and mechanical soil and water conservation measures have also been presented in details. The list of location specific SWC and agro-forestry measures for vulnerable districts has been compiled as ready reckoner for policy makers, researchers, planners, NGOs and extension functionaries working to address the various land degradation problems.

(Authors)

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1.0 INTRODUCTION

Soil is one of the vital natural resources of the earth. In India 70% population of rural household still depend primarily on agriculture for livelihood, therefore it is imperative to maintain the quality and productivity of soils to meet the demand sustainably. In recent times, there is an increasing trend observed in degraded areas and particularly water induced soil erosion has increased manifolds. Wind and improper tillage operation are also major threats to the soil ecosystem. Improper land management practices, deforestation, increasing population, changing climate and anthropogenic activities have not only affected the soil productivity by removing the nutrient-rich top soil but also the physical, chemical and biological property of soil altogether. Although soil erosion is a global phenomenon and occurs naturally under all climatic conditions however in recent years there is a significant increase in soil erosion rate mostly due to anthropogenic activities. The risk of soil erosion in West Bengal is major concern as coastal wind, coastal wave, high and intense rainfall, littoral drift (also known as long shore drift: it is a geological process that consists of the transportation of sediments along a coast parallel to the shoreline), storm surges, rugged terrains and human interventions accelerate the erosion rate. West Bengal is observed with 19.54% of the total geographical area under desertification/ land degradation for the period of 2011-13 (Desertification and Land degradation Atlas of India, 2016). The desertification/ land degradation area in West Bengal has increased about 0.59% since 2003-05. The most significant process of desertification/ land degradation in the state is water erosion (14.98% in 2011-13 and 14.64% in 2003-05) followed by vegetation degradation (2.99% in 2011-13 and 2.98% in 2003-05) (Desertification and Land degradation Atlas of India, 2016).

Frequent cyclones in the coastal region of West Bengal leads to strong winds, tidal movement and unprecedented rainfall events, thereby causing rapid soil erosion (Srinivasan *et al*., 2022). The state West Bengal experiences 1.00 q ha^{-1}, 0.58 q ha^{-1} and 0.46 q ha^{-1} of annual productivity loss due to water erosion from rainfed cereal, oilseed and pulse crops respectively (Sharda and Dogra., 2013). The state also has witnessed a significant escalation in the severity of climate change through occurrence of extreme events as reported by Center for Science and Environment (CSE), New Delhi**.**

Agricultural sector is a prime sector of the economy of West Bengal where expansion of the industrial sector is limited due to its topographical constraints (Sarkar and Ghosh, 2017). In the state, there is the coexistence of developed and developing districts. A recent report by NABARD claims 20% of the people of West Bengal still live below the poverty line and the average size of land holding is only 0.77 ha.

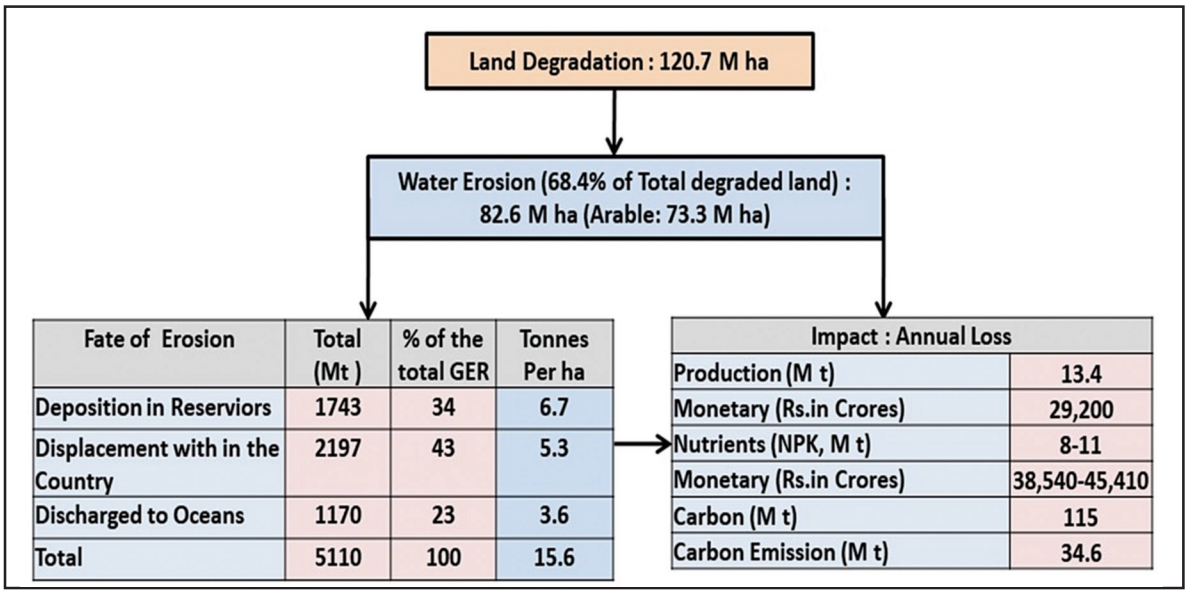
West Bengal is an agrarian economy and nearly 70% of its population depends on farming. Therefore; the need of the hour is to assess the soil erosion risk and its remedial measures to preserve and restore the soil productivity as well as to understand soil conservation and future strategies for watershed management. Hence erosion risk assessment would be of great importance for policy makers, scientists and land managers to identify the vulnerable areas so that they can take effective agronomical and engineering practices for better crop production and sustainability of the soil ecosystem. This document is a step forward in the direction of formulating specific strategies for soil and water conservation for the most affected districts of the state, so that as per the erosion risk and priority which will guide all stakeholders for decision making for sustainable land management.

This report is a detailed compilation of district wise soil erosion problems in West Bengal along with the available soil and water conservation measures suitable to arrest the problem which will serve as a ready reckoner for land managers and farmers to address the soil erosion problems in their area.

2.0 LAND DEGRADATION THROUGH SOIL EROSION AND ITS IMPACTS

2.1 Land degradation:

Land degradation is caused by multiple forces, including extreme weather conditions. Particularly soil erosion is one of the India's most pressing environmental problems. Almost all Indian states have recorded an increase in degraded land in the past 15 years (Desertification and Land degradation Atlas of India, 2016). The above document reported that around 23.95% of desertification/land degradation with respect to total TGA of the country was contributed by Rajasthan, Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telengana in descending order. Currently in India, about 120.72 M ha (36.7% of TGA) area, has already been degraded. (Biswas *et al*., 2015). Of this 82.57 M ha (68.4%) is subjected to soil erosion by water which is more than 10.0 Mg ha^{-1} yr^{-1}. The soil erosion status and other associated losses in India are depicted in Fig. 2.1.



Fate of Erosion	Total (Mt)	% of the total GER	Tonnes Per ha
Deposition in Reserviors	1743	34	6.7
Displacement with in the Country	2197	43	5.3
Discharged to Oceans	1170	23	3.6
Total	5110	100	15.6

Impact : Annual Loss	
Production (M t)	13.4
Monetary (Rs.in Crores)	29,200
Nutrients (NPK, M t)	8-11
Monetary (Rs.in Crores)	38,540-45,410
Carbon (M t)	115
Carbon Emission (M t)	34.6

Fig. 2.1. Soil erosion and associated losses in India (GER- Gross erosion rate)

2.2 Gross erosion rate:

The gross annual soil erosion of our country is 5.11 billion tonnes out of which 34.11% deposited in the reservoirs, 22.90% is discharged outside the country (mainly to oceans), and 42.99% is displaced within the mainland (Sharda and Ojasvi, 2016). The average annual reduction in water storage capacity of dams is by 1.2% (data from 4937 big dams) and average life span reduction of the dams by 25 yrs (Range 8-53 yrs) due to sedimentation of the reservoirs.

2.3 Production loss and monetary loss:

The constant decline in soil quality is major factor responsible for reduction in crop yields. The annual production and monetary losses due to water erosion were estimated for 27 major rainfed cereals, oilseeds and pulses crops, to be 13.4 Mt (Sharda *et al*., 2010) valued at ₹ 29200 crore during 2015-16 (Sharda and Dogra, 2013).Particularly for West Bengal, the average production loss of cereal, oilseed and pulse crops were estimated to be 4%, 7% and 7%, respectively, and consequently, average loss considering cereals, oil seeds and pulses together was about 4%. Out of 0.34 million tonnes total production losses, 91.9% is due to losses in cereals and millets, 5.1% in oilseeds and 3.0% in pulses (Fig. 2.2).

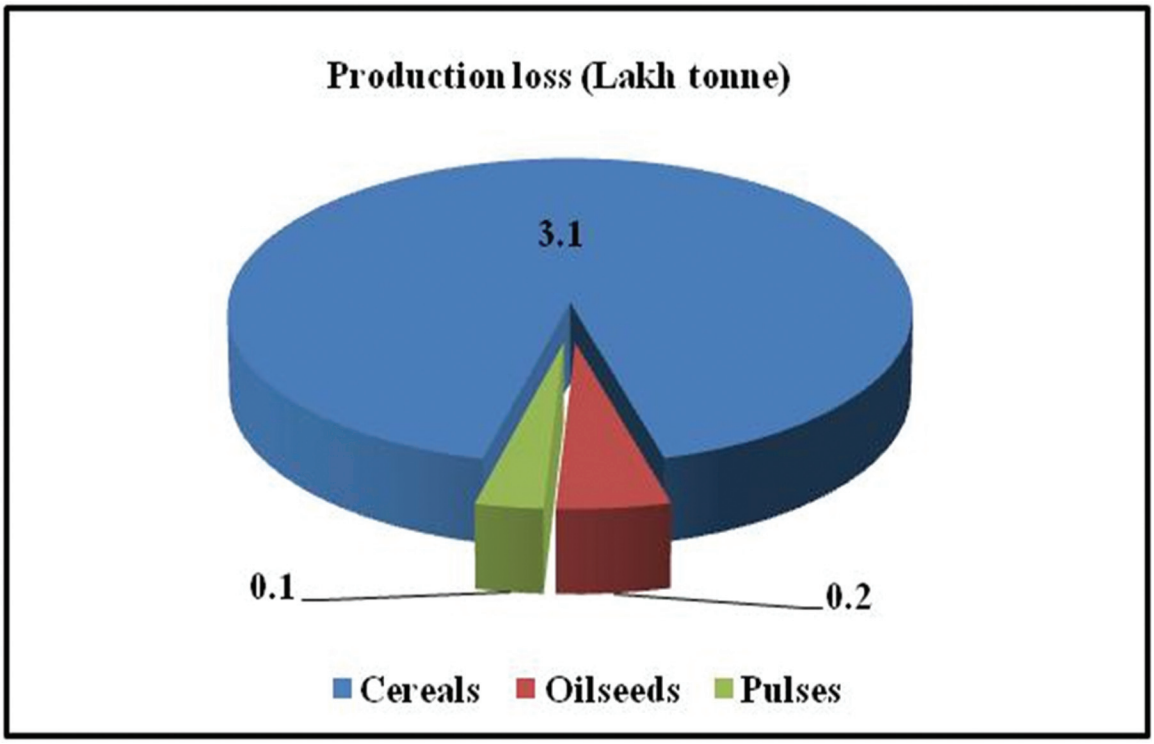


Fig. 2.2. Estimated total production loss of rainfed crops due to soil erosion in West Bengal

In terms of monetary losses, 79.9% of the total loss of Rs 6,819 million occurs in West Bengal due to production losses in cereals and millets, followed by 7.5% in pulses, and 12.8% in oilseeds (Fig. 2.3). The largest contribution is from paddy (72%) followed by other sesamum (6%), and rapeseed (6%). The average productivity loss of all these crops together is 94 kg ha^{-1} (Sharda and Dogra, 2013), which in monetary terms was Rs 1900 ha^{-1} during 2018-19 (Fig 2.4.). The Gross State Domestic Product (GSDP) of West Bengal for 2018-19 at current prices was estimated to be Rs 10,48,678 crore (PRS, 2019). Therefore, the State's loss due to soil erosion by rain water during the cultivation of rainfed cereal, oilseed and pulse crops is equal to 0.07% of its GSDP during 2018-19.

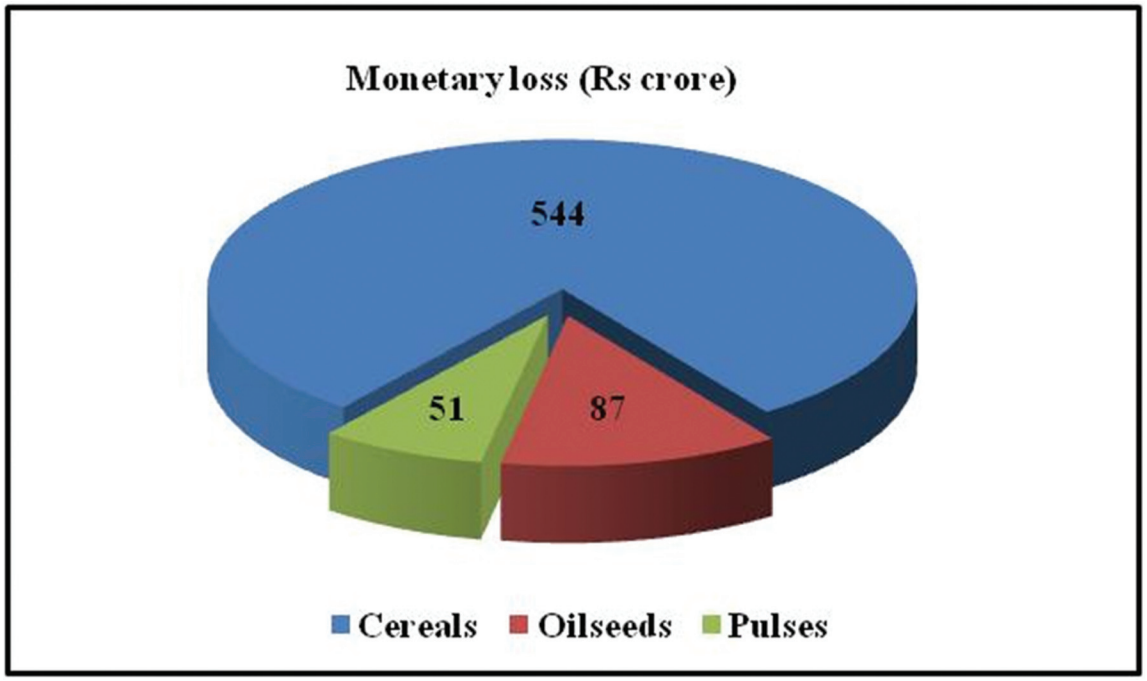


Fig. 2.3. Estimated total monetary loss of rainfed crops due to soil erosion in West Bengal

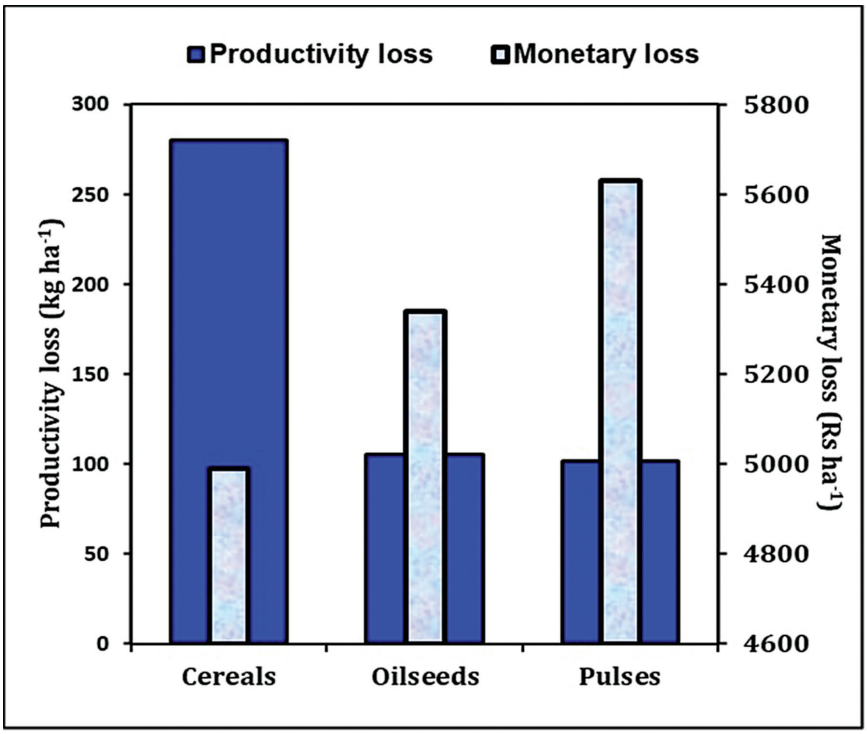


Fig. 2.4. Estimated productivity (kg ha^{-1}) and monetary loss (Rs ha^{-1}) of rainfed crops due to soil erosion in West Bengal

2.4 Nutrients loss:

Soil erosion by water results in loss of organic carbon, nutrient loss, decline in soil biodiversity, soil compaction, contamination with heavy metals and harsh fertilizers. According to NAAS, the annual soil loss rate in our country is about 15.35 t ha^{-1}, resulting in loss of 5.37 to 8.4 Mt of nutrients worth Rs.38,540 to 45,410 crores annually (As per 2020 price). An amount of 8 to 11 Mt of NPK gets washed off by runoff water and eventually leads to stagnating crop yield. The loss of soil nutrients has an immediate impact on crop production. Further the estimated erosion linked loss of N, P, K, and S nutrient displacement as 4.41 to 9.61, 0.387 to 2.31, 4.43 and 1.27-1.65 Mt amounting to the corresponding monetary loss of Rs.13500-29300, 1850-8320,17300 and 5890-7790 crore rupees (As per 2020 price), respectively.

2.5 Carbon loss:

Change in land use leads to soil erosion, a key element of degradation and loss of carbon flux from the soil (Bervic, 2012). Soil plays an important role to store the carbon and after erosion carbon escapes to the atmosphere which leads to increase in the greenhouse gases (GHGs). Soil serves as a largest terrestrial stock of carbon. The soil erosion and soil organic carbon are linked with each other,

which means more soil loss will lead to more loss of carbon from the soil. As a result of soil erosion, soil pool losses 1100 Mt C into the atmosphere and around 300-800 Mt C to the ocean annually (Lal, 2011). Quantity of organic C displacement due to water erosion in India is about 115 Mt yr^{-1} which consequently emits about 34.6 Mt of C to the atmosphere; erosion control can reduce C emission by 19.0–27.0 Mt yr^{-1} (Mandal et al., 2020).

2.6 Waterlogged areas and chemical degradation:

Waterlogging damages soil by causing salinization. In India due to waterlogging around 1.07 M ha area is under physical degradation. A total of 0.88 M ha area is subjected to permanent surface inundation whereas around 12.53 M ha land comes under fallow land due to temporary waterlogging during rainy season. Acidification, alkanisation, soil toxification through chemicals issues comes under chemical degradation of soil. About 6.74 M ha land affected by salinization comprising 3.79 M ha subjected to high sodicity. In Odisha, nearly 17,627 ha of land affected due to waterlogging alone, which is 0.20% of TGA of the state (Desertification and Land degradation Atlas of India, 2016).

2.7 Loss in Reservoir Capacity:

The eroded soil increases the sediment deposition and reduces reservoir capacity. The total gross capacity of (299.5 G m3) sediment trapped in the reservoirs was estimated about 1679 million cubic meter per year, due to sedimentation for longer period of time, the average annual capacity loss of the reservoirs was estimated as 1.04% with a range of 0.47 to 3.05% (Sharda and Ojasvi, 2016). Loss in reservoir capacity directly impact the irrigation regime in its command area therefore loss in crop production. In case of larger dams, it was observed that there is loss of 0.50 % to 0.80 % in gross storage capacity per year whereas in smaller dams 1 to 50 million cubic meter storage capacity loss was observed and it was ranging from 0.80% to > 2.00% per year.

3.0 THE APPROACH

Soil erosion risk depends upon the balance between prevailing soil erosion rate and the permissible rate or soil loss tolerance limit. While prevailing soil erosion rate is a function of physiographic, edaphic and climatic factors at a given location, the assessment of site-specific soil loss tolerance limit of the location helps in understanding capacity of the soil to withstand the forces of soil erosion. For example, about 32% areas of Peninsular Plateau can only afford a soil loss ranging from 2.5 to 7.5 t ha^{-1} yr^{-1} (NAAS, 2017, Biswas et al., 2015) while soil erosion rates in such area is more than 10 t ha^{-1} yr^{-1}.

The district wise prioritization/risk area was assessed from the database on potential soil erosion rates and soil loss tolerance limits for the state of West Bengal. The potential soil erosion rate was compared with the value of soil loss tolerance limit, the differences in value of potential soil erosion and soil loss tolerance limit of a place was used for deciding priority class, higher the difference (Potential soil erosion rate – soil loss tolerance limit), higher the priority. Based on the difference of soil erosion and tolerance limits, five priority classes have been defined normalizing the difference values between 35 and 5 t ha^{-1} yr^{-1}(Class 1 > 35 t ha^{-1} yr^{-1}, Class 2: 25 to 35 t ha^{-1} yr^{-1}, Class 3: 15 to 25 t ha^{-1} yr^{-1}, Class 4: 5 to 15 t ha^{-1} yr^{-1}, and Class 5 < 5 t ha^{-1} yr^{-1}). In addition to the above difference, an area having T-value of 2.5 t ha^{-1} yr^{-1} is considered most sensitive due to shallow soil depth and poor quality. It is highly vulnerable to loss of crop productivity if soil erosion exceeds the T–value. This makes the Eastern region of India an area of great concern from soil erosion point of view. From operational point of view, the sum of priority class 1, 2 and 3 has been taken into consideration and the severity of soil erosion risk has been reclassified. According to this re-classification, severity class A, B and C were defined based on the cumulative area of < 50000 ha, 50000-100000 ha and > 100000 ha, respectively (Kannan et al, 2021).

Soil erosion in a given priority class has to be brought within the permissible rate or T-value to achieve sustainability of production systems, and for carbon sequestration. The identification of critical areas in the priority classes based on the permissible soil erosion rate or T-value at a given location in each district of West Bengal and the proposed conservation measures for each district are aimed to reduce soil erosion below the soil tolerance limit.

4.0 EROSION STATUS AND CONSERVATION PLANNING FOR THE STATE OF WEST BENGAL

4.1 About the State

The state of West Bengal is situated between 21° 25' 24" N to 27° 30' 15" N latitudes and between 85° 48' 22"E to 89° 53' 04"E longitudes. The total geographical area of the state is 8.87 M ha, which is 2.70% of total area of India. It has a coastline of 157.50 km along the Bay of Bengal. The state has a rural population of about 68.13% and urban population of 38.80%. It extends from the Himalayas in the north to the Bay of Bengal in the south. It is surrounded by the neighboring countries such as Bangladesh, Nepal and Bhutan. It also shares the boundaries with Indian states like Assam, Sikkim, Bihar, Jharkhand and Odisha. It has four major geographical regions- the Chotanagpur plateau region in its northwestern parts, the Himalaya mountain region, the lower Gangetic plain region and the coastal belt. Bhagirathi, Mayurakshi, Damodar, Kangsabati, Teesta, Torsha, Jaldhaka, Mahananda, Subarnarekha, Hooghly, Ganges, Damodar and Rupnarayan are the main rivers of this state. In West Bengal, there is a huge variation in topography, having coastal plains in the southern part, whereas north hilly regions are as high as 3616 m (Fig. 4.1).

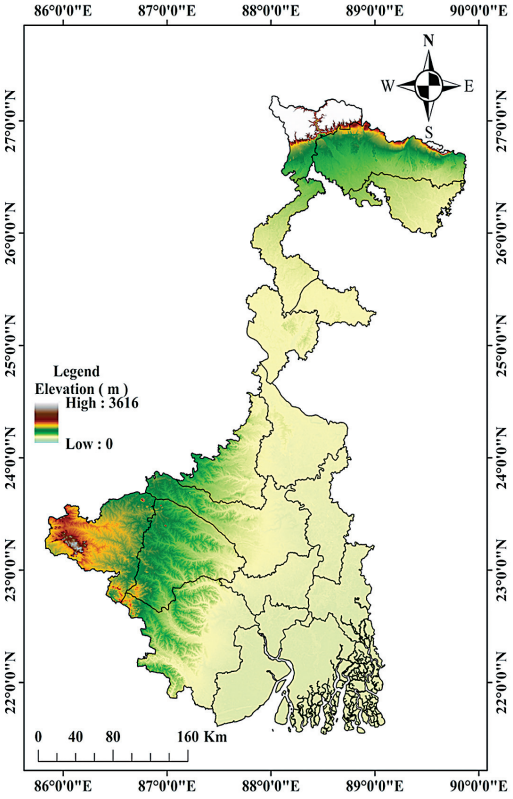


Fig. 4.1. Elevation map of West Bengal

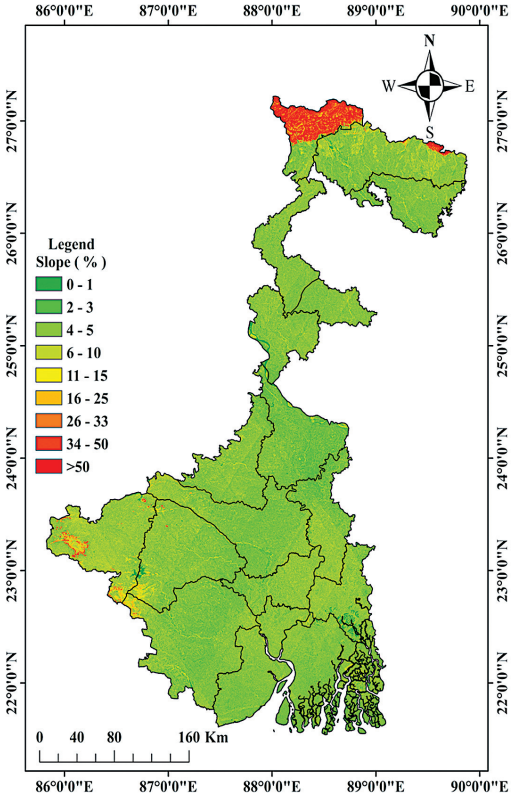


Fig. 4.2. Slope map of West Bengal

The slope map of the state is shown in Fig. 4.2. In the state, maximum area (3655.41 thousand ha) falls under slope of 0-1%, which is 41.19% of total geographical area of the state, followed by area under slope category 1-3% and 3-5%. The geography of West Bengal includes the Darjeeling Himalayan hill region, Terai, undulating plateau, fertile alluvial plain and Sundarbans delta. The Ganges, Damodar, Kangsabati and Bhagirathi-Hooghly are the major rivers flowing through the state. The Gangetic plain is rich in alluvial soil and thus is very fertile and suitable for agriculture.

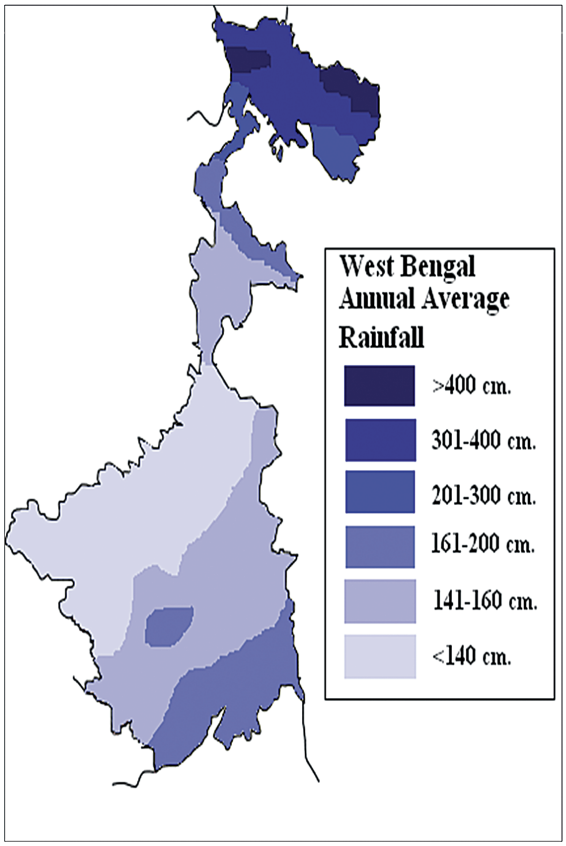


Fig. 4.3. Spatial variation of mean annual rainfall in West Bengal

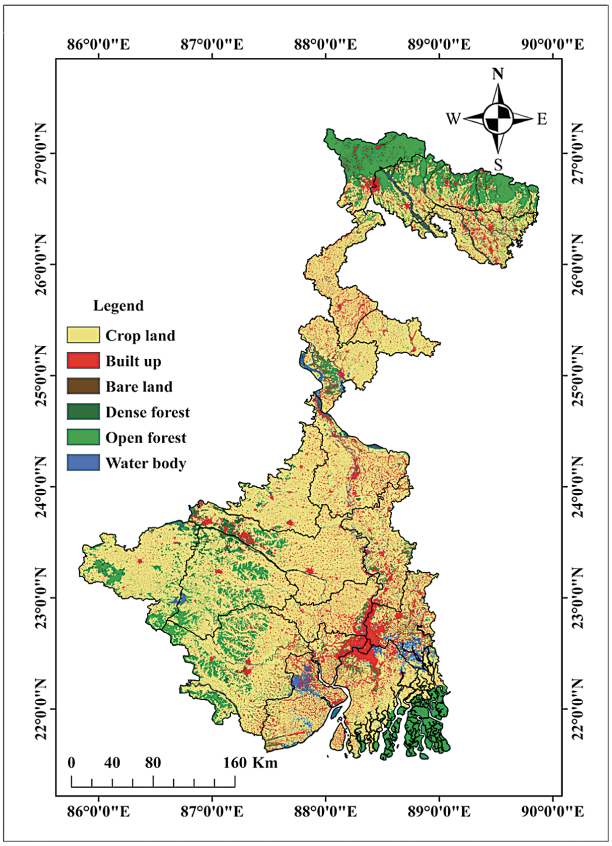


Fig. 4.4. Landuse map of West Bengal

The state's climate varies from tropical savanna in the southern portions to humid subtropical in the north. The main seasons are summer, rainy season, a short autumn and winter. While the summer in the delta region is noted for excessive humidity, the western highlands experience a dry summer like northern India. The highest daytime temperatures range from 38^{O}C to 45^{O}C (Banerjee and Biswas, 2020). Winter is mild over the plains with average minimum temperatures of 15^{O}C. The annual rainfall of West Bengal ranges 1400 to 4000 mm across the state (Fig. 4.3). Average normal rainfall is 1830

mm, for the State. Out of total rainfall, about 70% to 75% occurs in the monsoon season. The state is prone to cyclones, flood and drought and natural disasters occur in most of the districts every year. The state West Bengal has been divided into 23 administrative districts.

The state is an agrarian state and its economy is dependent on agriculture and allied sector. Nearly about 60% population of the state earn their livelihood through agriculture. Agricultural production system in West Bengal is dominant by small-holder farmers. The state has 5.20 M ha of net cropped area, 9.90 M ha of gross cropped area and the cropping intensity is 188%. The cropping pattern is dominated by food-grain crops (68%), mainly paddy (55%), followed by other food crops such as potato (4.27%), pulses (3.45%), wheat (3.40%), maize (1.53%), spices and condiments (1.30%).

4.2 Soil erosion rate:

Analysis of soil erosion data revealed that soil erosion rates vary enormously across the state. About 1.77 % and 2.49% area come under severity risk A (<50000 ha), and B (50000-100000 ha) respectively. Percentage of area under slight erosion (5-15 t ha^{-1} yr^{-1}), moderate (15-25 t ha^{-1} yr^{-1}) and severe (25-35 t ha^{-1} yr^{-1}) soil erosion classes are 3.76, 3.06 and 1.19 respectively. Soil erosion data indicates that erosion is a serious problem in major parts of the state. The severity of soil erosion is due to undulating topography, high and intense rainfall, frequent occurrence of flooding and cyclone coupled with high wind velocity, changing land use, mining, deforestation apart from coastal erosion due to high tides (Lenka et al., 2012).

4.3 Soil loss tolerance limit (SLTL):

Data pertaining to soil loss or erosion tolerance limits indicated that it varies between 2.5 and 12.5 t ha^{-1} yr^{-1}. The areas having lower T-values ranging from 2.5 to 5.0 t ha^{-1} yr^{-1} are most sensitive and need greater attention for adopting soil and water conservation measures to minimize further deterioration. Soil erosion risk map of the state showing different priority classes and their extent is given in Fig. 4.5.

4.4 Production and monetary loss from rainfed crops due to soil erosion: -

West Bengal suffers from higher crop productivity losses than the national average (2.10-2.90 q ha^{-1}) in case of cereals whereas loss of < 1.05 q ha^{-1} and 1.01q ha^{-1} estimated in case of oilseeds and pulses respectively. Cumulative productivity losses of rainfed crops in the state is 2.0 q ha^{-1} due to water induced erosion.

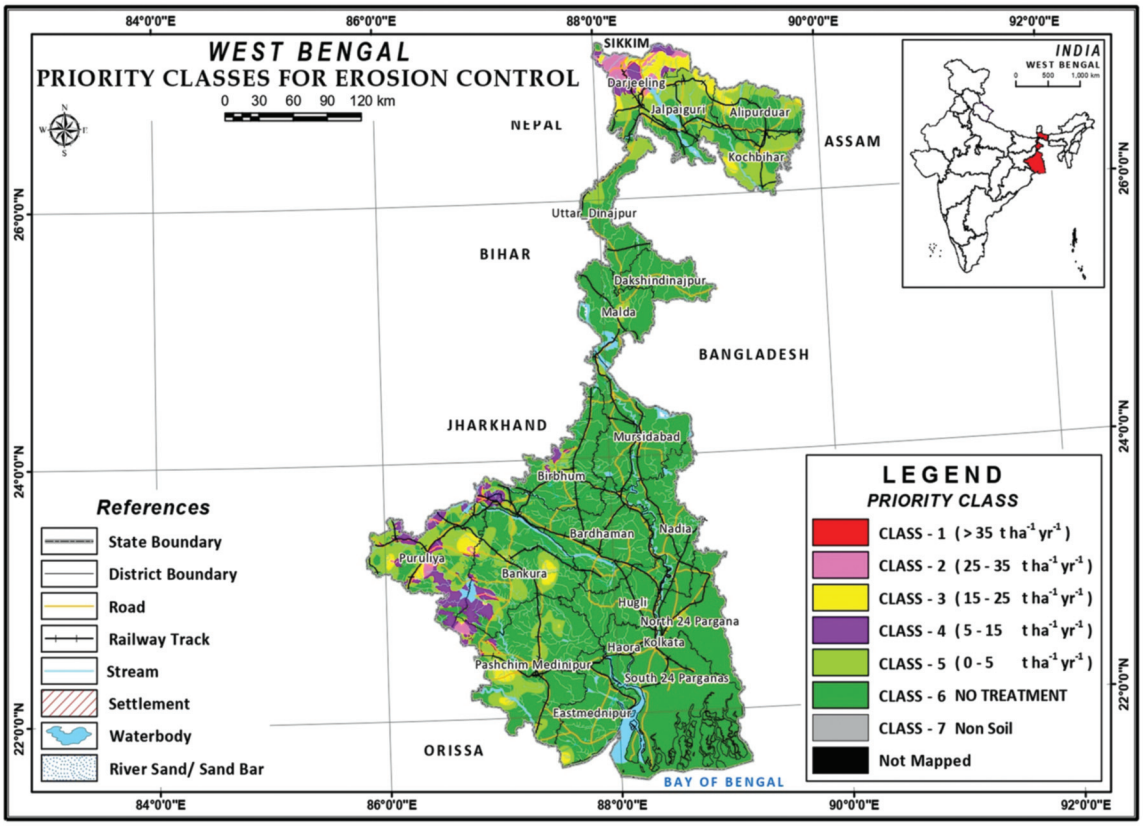


Fig. 4.5. Priority classes for erosion control in West Bengal

4.5 Area under risk:

It is evident that 27.95% of TGA of the state requires different degrees of soil erosion management and rest part of TGA falls under no treatment category in view of the fact that soil loss is within permissible erosion limits. Similarly, though 14.25% area has prevailing soil erosion rates of 5-15 t ha^{-1} yr^{-1} whereas 7.97% and 5.66% area still falls under 15-25 t ha^{-1} yr^{-1} and 25-35 t ha^{-1} yr^{-1} respectively. Delineating critical land degradation areas through prioritization process is crucial for development and implementation of suitable conservation measures that can help in protecting soil and water resources, and in turn the ecosystems. Detail account of district wise severity of erosion areas and critical problem with their possible solutions has been given in Table 4.1. The last column of Table 4.1 refers to possible conservation measures needs to be implemented in the district, and taken from Table 4.2 and Table 4.3 which are given in the succeeding sections of the document. Table 4.2 indicates soil and water conservation measures suitable under different land situations, Table 4.3 presents district wise agronomic and vegetative measures and Table 4.4 presents agro-climatic zone wise agro-forestry measures.

Table 4.1. District wise severity of erosion areas and critical problem with their possible solutions in West Bengal

S N	District	TGA (000, ha)	Net sown area (000, ha)	Area under risk ('000 ha)	% of TGA	Special problem	Solutions measures
Severity of Risk-A							
1	East Medinipur	473.60	292.73	7.92 (3:7.92)	1.67	Cyclone, Drought, erosion, flood, sea water intrusion	Table 4.2- Sl. No. 1.3, 1.5, 1.7, 2.4, 2.5, 2.7, 3.1.1, 3.2.3, 3.2.5, 3.2.7, 3.3.5, 4.3, 4.4, 4.6, 5.1, 5.3, 5.4, 5.6, 6.1.7, 6.2.12, 7.12, 7.4
2	Coochbehar	338.70	248.10	11.06 (3:11.06)	3.26	Drought, erosion, flood, hail storm	Table 4.2- Sl. No. 1.3, 1.5, 1.7, 2.4, 2.5, 2.7, 3.1.1, 3.2.3, 3.2.5, 3.2.7, 3.3.5, 4.3, 4.4, 4.6, 5.1, 5.3, 5.4, 5.6, 6.1.7, 6.2.12, 7.12, 7.4
3	Bankura	688.20	345.40	28.94 (2:0.06, 3:28.88)	4.20	Drought, erosion	Table 4.2- Sl. No. 1.5, 1.7, 2.4, 2.5, 2.7, 3.1.1, 3.2.3, 3.2.5, 3.2.7, 3.3.5, 4.3, 4.4, 4.6, 5.1, 5.3, 5.4, 5.6, 6.1.7, 6.2.12, 7.12, 7.4
4	Alipurduar	313.60	335.7	30.65 (3:30.65)	9.77	Drought, erosion, flood	Table 4.2- Sl. No. 1.3, 1.5, 1.7, 2.4, 2.5, 2.7, 3.1.1, 3.2.3, 3.2.5, 3.2.7, 3.3.5, 4.3, 4.4, 4.6, 5.1, 5.3, 5.4, 5.6, 6.1.7, 6.2.12, 7.12, 7.4
5	Jalpaiguri	338.60	335.7	37.06 (2:5.93, 3:31.13)	10.94	Erosion, flood	Table 4.2- Sl. No. 1.1, 1.3, 1.5, 1.7, 2.4, 2.5, 2.6, 2.7, 3.1.1, 3.1.2, 3.2.7, 4.3, 4.4, 4.6, 4.8, 5.2, 5.4, 6.1.7, 6.2.12, 7.4
6	West Medinipur	935.82	558.70	41.50 (2: 10.59, 3:30.91)	4.43	Drought, erosion, flood	Table 4.2- Sl. No. 1.1, 1.3, 1.5, 1.7, 2.4, 2.5, 2.6, 2.7, 3.1.1, 3.1.2, 3.2.7, 4.3, 4.4, 4.6, 4.8, 5.2, 5.4, 6.1.7, 6.2.12, 7.4
Total	**Risk-A**	**6317.00**	**2059.00**	**304.33**	1.95		
Severity Risk –B							
7	Purulia	625.90	317.00	59.73 (1:0.0006, 2:16.97, 3:42.76)	9.54	Drought, erosion	Table 4.2- Sl. No. 1.5, 1.7, 2.4, 2.5, 2.7, 3.1.1, 3.2.3, 3.2.5, 3.2.7, 3.3.5, 4.3, 4.4, 4.6, 5.1, 5.3, 5.4, 5.6, 6.1.7, 6.2.12, 7.12, 7.4
8	Darjeeling	314.90	143.86	160.89 (1: 0.003, 2:72.16, 3:88.73)	51.09	Erosion, Flood, landslides	Table 4.2- Sl. No. 1.1, 1.3, 1.5, 1.7, 2.4, 2.5, 2.6, 2.7, 3.1.1, 3.1.2, 3.2.7, 4.2, 4.3, 4.4, 4.6, 4.8, 5.2, 5.4, 6.1.7, 6.2.12, 7.4
Total	**Risk-B**	**4456.00**	**1291.00**	**1459.60**	**9.37**		

Note 1: District wise details of agronomic and vegetative measures for Odisha referred in Table P is given in Table P1

Note2 : A= < 50,000 ha area is critical; B= between 50,000-1,00000 ha area is critical; C= > 1,00000 ha area is critical in a district. Critical area is the sum of area under priority class 1, 2 and 3. Data in Parentheses shows area under different priority class based on difference between potential erosion (Er) and soil loss tolerance limit (T) i.e. (E_r – TL); 1: (E_r – TL) >35 t ha^{-1} yr^{-1}, 2: (E_r – TL) in the range of 25-35 t ha^{-1} yr^{-1}, 3: (E_r – TL) in the range of 15-25 t ha^{-1} yr^{-1}. Table P represents different soil and water conservation measures for different land situations and Table Q represents district wise potential agroforestry systems (AFS).

Table 4.2. Soil and water conservation measures for different soil erosion priority classes

S No	Conservation Measures	Slope <10%		Slope-10-33%	
		Low priority class		High priority class	
		Arable land	Non-arable land	Arable land	Non-arable land
1.0	**Agronomic Measures (upto 6% slope, agronomic measures alone; >6% slope with other land management practices)**				
1.1	Contour cultivation/farming	√		√	
1.2	Inter or mixed cropping	√		√	
1.3	Green manuring and recycling crop residues	√		√	
1.4	Crop rotation	√		√	
1.5	Mulching	√		√	
1.6	Conservation tillage/Conservation agriculture	√		√	
1.7	Cover crop	√		√	
1.8	Fodder/medicinal-aromatic grass on the bunds and terrace riser			√	
1.9	Broad bed and furrow (Black soil)	√			
1.10	Furrow opening in between the lines (Black soil)	√			
2.0	**Vegetative measures (At lower slope-alone, at higher slope with other conservation measures**				
2.1	Vegetative barrier*/mixed vegetative barriers*	√	√	√	√
2.2	Vegetative strips*		√	√	√
2.3	Vegetally* guarded conservation trenches and ridges (VGCTR)		√		√
2.4	Afforestation/reforestation		√		√
2.5	Grassed waterways	√	√	√	√
2.6	Live vegetative check dam (Bamboo)		√		√
2.7	Stream bank stabilization with bamboo and other species		√		√
	*Species: Sambuta grass (*Saccharum munja*), Vetivera grass (*Vetiveria zinanoides*) ; Guatemala grass (*Tripsacum laxum*); Weeping love grass (*Eragrostis curvula);* Lemon grass (*Cymbopogon citrates); citronella grass,* Rosha/ palma rosa grass (*C. martinii);* Malabar (*C. flexuosus);* Hybrid Napier; Agave (*Agave Americana & Agave sisalana);* Geranium (*Pelargonium graveolens);* Mulberry (*Morus alba); Pineapple (Ananas comosus)*				
3.0	**Mechanical/engineering measures**				
3.1	**Bunding**				
3.1.1	Contour/field bunding/trench-cum-bund	√	√	√	√
3.1.2	Graded bunding (uniformly and variable graded)-Black soils	√			
3.1.3	Stone bund (depending on availability of stones onsite)	√	√	√	√
3.1.4	Compartmental bunding	√		√	
3.2	**Trenching**				
3.2.1	Contour trenching		√		√
3.2.2	Continuous contour trenching		√		√
3.2.3	Contour staggered trenching		√		√
3.2.4	Graded trenching		√		√
3.2.5	Water absorption trenches		√		√

3.2.6	Half-moon trenches/terraces	√	√	√	√
3.2.7	Recharge pit		√		√
3.3	**Terracing (Bench)**				
3.3.1	Leveled terrace	√		√	
3.3.2	Inward sloping	√		√	
3.3.3	Outward sloping	√		√	
3.3.4	Puertorican type/vegetative	√		√	
3.3.5	Half-moon terraces			√	√
3.3.6	Conservation bench terracing	√			
3.3.7	Narrow based terracing			√	
4.0	**Drainage line treatments (DLTs)**				
4.1	Earthen check dam		√		
4.2	Sandbag check dam		√		
4.3	Brush wood check dam		√		√
4.4	Loose boulders check dam (LBCD)		√		√
4.5	Gabion		√		√
4.6	RCC check dam		√		√
4.7	Gabion terrace support wall		√		√
4.8	Retaining wall/ Revetment		√		√
4.9	Silt detention tank		√		√
5.0	**Water harvesting**				
5.1	Community pond	√	√	√	
5.2	Embankment pond		√		
5.3	Pond renovation and desilting	√	√	√	
5.4	Farm pond-dugout	√		√	
5.5	Subsurface runoff collection wells			√	
5.5	Pond lining	√	√	√	
5.6	Roof top water harvesting	√		√	
5.7	Diversion based water harvesting			√	√
	Special problem area				
6.0	**Mine spoil area/ land slide prone area**				
6.1	**Vegetative**				
6.1.1	Vegetative hedges		√		√
6.1.2	Brushwood check dam				√
6.1.3	Watling (live)				√
6.1.4	Double-row brushwood dam / log wood brush filled check dam				√
6.1.5	Grassed contour barrier		√		√
6.1.6	Bamboo/Casurina/Cashew/Eucalyptus plantation		√		√
6.1.7	Afforestation		√		√
6.1.8	Aerial seeding (very high slope or unapproachable area)				√
6.1.9	Turfing/soding				√
6.2	**Mechanical/engineering measures**				
6.2.1	Contour bund/stone bund		√		√

6.2.2	Stone wall				√
6.2.3	Staggered trench with planting		√		√
6.2.4	Loose boulder check dam (locally available)				√
6.2.5	Diversion drain/ Interceptor drain				√
6.2.6	Nala bund		√		
6.2.7	Gabion check dam				√
6.2.8	Gabion drop structure				√
6.2.9	Toe wall/toe drain				√
6.2.10	Retaining wall				√
6.2.11	Jute geo textiles for slope stabilization/ Coir Jeo textiles for stabilization of land slide areas (Slope >33%)				√
6.2.12	Stream channelization (retaining wall, bank protection walls. spurs with apron etc)		√		√
7.0	**Gullied and ravine land**				
7.1	Bio fencing/social fencing		√		√
7.2	Peripheral bund		√		√
7.3	Peripheral bund supported by close plantation of bamboo		√		√
7.4	Safe disposal of water from gully head-Piped/chute spillway		√		√
7.5	Bamboo on ravine bed and grass on slope		√		√
7.6	Bamboo based live check dam		√		√
7.7	Alternate land use system/Agro-forestry		√		√
7.8	Mechanical/engineering measures		√		√
7.9	Earthen check dam		√		√
7.10	Boribund check dam		√		√
7.11	Silt retention tank		√		√
7.12	Staggered trenching + plantation		√		√
8.0	**Coastal erosion**				
8.1	Vegetative				
8.1.1	Plantation of mangroves and other associated species				
8.1.2	Sowing and in-situ ploughing of green manure species				
8.1.3	Bio shielding of the coast through native species of				
	grass and trees (*Spinifexlittoreus, Ipomoea pes-*				
	caprae, Canavalia spp, Pandanus spp, Borassus				
	flabellifer and *Morinda citrifolia*)				
8.2	Mechanical/engineering measures				
8.2.1	Offshore breakwater (natural boulders)				
8.2.2	Revetment like upright barricades parallel to sea				
8.2.3	Riprap rock armour				
8.2.4	Groynes				

Note 1: District wise details of agronomic and vegetative measures for Odisha, in is given in Table 4.3**Note 2**: For concept, design and estimates of soil and water conservation measures, kindly refer- Mishra, PK., Jual, GP., Tripathi, KP., Ojasvi, PR., Shrimali, SS., Sena, DR., Kumar, A., Patra, S. (2017). Field manual on soil and water conservation structures, ICAR, New Delhi, ISBN: 978-81-7164-167-3Note 3: For agro-forestry solution for soil water conservation in Odisha, refer Table 4.4.

Table 4.3. District wise agronomic and vegetative SWC measures in West Bengal

[District Details: Name of District, Total Geographical area, TGA (000, ha), area under erosion risk (A(Er)) ('000 ha), erosion risk area as a percentage of TGA (Er (%)), Special erosion problem (Sp.P)]				
S. N.	**Cropping System (Intercropping, mixed cropping, Conservation Agriculture, crop rotation, etc.)**	**Green manuring, Cover crops and Mulching**	**Protection-cum Productive Vegetative Barriers (Grasses/Fodder/Medicinal-Aromatic Crops /Tea/ etc.)**	**Special problem area: Grassed waterways/live check dams/Mine spoil area/ Land Slide Prone Area**
	Severity of Risk-A			
1.	**District: East Midnapore, TGA:473.60, A(Er):7.92(3:7.92), Er (%):1.67%, Sp.P: Coastal erosion, cyclone, drought, flood, sea water intrusion**			
	Existing cropping system: Rice–fallow, rice–rice, rice–vegetables, rice–oil seed/pulses (black gram, green gram, sesamum) **Possible cropping and inter cropping system:** Inter cropping of vegetables and flowers Colocassia – green gram/black gram, rice and paira (relay) cropping with lathyrus, lentil, rice-ridge potato, rice-ridge potato-green gram	Green manuring with *Sesbania bispinosa and Crotalaria juncea* during summer in the rice field.Cow pea as cover crop.	Horticulture/plantation crop: Coconut, sapota, citrus, papaya, banana, and mango. Fodder crop: Berseem, lucerne, gunea grass and combo grass.	Sea water intrusion to agriculture lands: Leaching, selection of salt tolerant varieties (*Lunishree*). Bio-shielding of the coast through planting of following species of grass and trees such as: *Spinifex littoreus, Ipomoea pes-caprae, Canavalia spp, Pandanus spp, Borassus flabellifer* and *Morinda citrifolia.*Plantation: Plantation of mangrove species such as *Sonneratia apetal*, *Heritiera fomes* etc.SWC measures : Groynes, gabion, revetments, sand dune stabilization through vegetation and strengthening of embankments
2.	**District: Coochbehar, TGA: 338.70, A(Er): 11.06(3:11.06), Er (%): 3.26%, Sp.P: Drought, erosion, flood, hail storm**			
	Existing cropping system: Jute-rice, rice-toria, rice-vegetables **Possible cropping and inter cropping system :** Rice –jute-rice, Potato-jute- Inter cropping of rice + Arhar (5:2), rice + green gram/black gram (3:1), Maize + cow pea (2:2), maize + runner bean (2:2).Growing of field pea, lentil and chickpea after rice as relay crop.	Green manuring with *Sesbania bispinosa and Crotalaria juncea* during summer in the rice field.Cow pea as cover crop.	Horticulture/plantation crop: Arecanut coconut, jack fruit, litchi, guava, beetle vine Bund planting with cow pea, green gram and black gram. Fodder crop: S*tylosanthee*, *Dinanath* grass on the field bund.	Drought: Construction of rain water harvesting structures, use of micro irrigation, plantation of drought tolerant grasses, shrubs and trees, use of mulch to retain soil moisture.Flood: Installation of rock berms, rock rip-raps and flood walls, stream bank protection works, and strengthening of embankments

3.	**District: Bankura, TGA:688.20, A(Er):28.94(2:0.06, 3:28.88), Er (%):4.20, Sp.P: Drought, erosion**			
	Existing cropping system: Rice-fallow, rice-wheat/mustard/ vegetables **Possible cropping and inter cropping system :** Inter cropping of arhar + groundnut (2:6) Growing of field pea, lentil and chickpea after rice as relay crop.	Green manuring with *Sesbania bispinosa, legumes and Crotalaria juncea.* Cowpea and beans as cover crop	Horticulture/plantation crop: Mango, banana, papaya, guava, jack fruit Bund planting with cow pea, green gram and black gram. Growing of grasses like *stylosanthee*, *Dinanath* grass on the field bund for fodder.	Drought: Inter-cultivation (Soil mulching, conservation furrow, organic mulching with previous crop residues, compartmental bunding, adoption of ridge and furrow method of planting vegetable cropsErosion: Field bunding, stream bank protection works, and strengthening of embankments, construction of earthen and stone bunds, vegetative barrier.
4.	**District:Alipurduar, TGA:313.60, A(Er):30.65(3:30.65), Er (%):9.77, Sp.P:Drought, erosion, flood**			
	Existing cropping system: Jute-rice, rice-toria, rice-vegetables **Possible cropping and inter cropping system :** Rice-potato/mustard/vegetable, rice-wheat/mustard Inter cropping of rice + arhar (5:2), maize + cow pea (2:2)	Green gram as in-situ green manuring crop.	Pine apple, banana, jack fruit, arecanut, black peper, fenu greek, beetle vine Growing of grasses like napier, para and gunea on the field bund for fodder.	Drought: Inter-cultivation (Soil mulching, conservation furrow, organic mulching with previous crop residues, compartmental bunding, adoption of ridge and furrow method of planting vegetable cropsErosion: Field bunding, stream bank protection works, and strengthening of embankments, construction of earthen and stone bunds, vegetative barrier, Flood: Groynes, gabion, revetments, RCC chek dams, installation of rock berms, rock rip-raps and flood walls.
5.	**District: Jalpaiguri, TGA:338.60, A(Er):37.06(2:5.93, 3: 31.13), Er (%):10.94, Sp.P: Erosion, flood**			
	Existing cropping system: Jute-rice, rice–toria, **Possible cropping and inter cropping system :** Rice–sugarcane + green gram Inter cropping of brinjal + maize /arhar, arhar + cowpea/maize (2:2), arhar + sesamum (2:4), arhar + radish (2:2), arhar + horse gram/black gram (2:3), arhar + rice (2:5)	Green manuring with *Sesbania bispinosa, legumes and Crotalaria juncea*. Cowpea, pumpkin, cluster bean as cover crop.	Pine apple, banana, jack fruit, arecanut, black peper, fenu greek, beetle vine Cultivation of napier grass along the bunds to reduce erosion and augment fodder production to animals.	Erosion: Field bunding, stream bank protection works, and strengthening of embankments, construction of earthen and stone bunds, vegetative barrier, Flood: Groynes, gabion, revetments, RCC chek dams, installation of rock berms, rock rip-raps and flood walls.
6.	**District: West Midnapore, TGA : 935.82, A(Er) : 41.50 (2:10.59, 3:30.91), Er (%) : 4.43, Sp.P : Drought, erosion, flood**			
	Existing cropping system: Sole crops : Rice-wheat/mustard/vegetables,	Cowpea, pumpkin, cluster bean as cover crop. *Gliricidia* as green manuring crop on the field bund.	Horticultural crop: Mango, banana, jack fruit, papaya, guava.Similarly irrigated areas have potential to grow flowers (tube rose, marigold) apart from seed production.	Drought: Inter-cultivation (Soil mulching, conservation furrow, organic mulching with previous crop residues, compartmental bunding,

	Possible cropping and inter cropping system : Maize-wheat, Groundnut-wheat, rice-khesari/linseed, rice-pulses, rice-oilseed(mustard / rapeseed) Inter cropping of arhar + groundnut (2:5), maize + cowpea (2:2),			adoption of ridge and furrow method of planting vegetable cropsErosion: Field bunding, stream bank protection works, and strengthening of embankments, construction of earthen and stone bunds, vegetative barrier. Flood: Groynes, gabion, revetments, RCC chek dams, installation of rock berms, rock rip-raps and flood walls.
7.	**District: Purulia, TGA : 625.90, A(Er): 59.73 (1:0.0006, 2:16.97, 3:42.76), Er (%) : 9.54, Sp.P: Drought, erosion**			
	Existing cropping system: Rice-wheat/mustard/vegetables, **Possible cropping and inter cropping system :** Rice–green gram/black gram/water melon, rice-sunflower Inter cropping of arhar + groundnut (2:5), arhar + sesamun (2:4), maize + cowpea (2:2)	Green manuring with *Sesbania bispinosa, legumes and Crotalaria juncea.* *Gliricidia* as green manuring crop on the field bund.	Mango, papaya, banana, pine apple, guava.Bund planting with yam and elephant foot yam. Horiculture/ plantation crop: Custard apple, litchi, mango, citrus.	Drought: Inter-cultivation (Soil mulching, conservation furrow, organic mulching with previous crop residues, compartmental bunding, adoption of ridge and furrow method of planting vegetable cropsErosion: Field bunding, stream bank protection works, and strengthening of embankments, construction of earthen and stone bunds, vegetative barrier.
8.	**District: Darjeeling, TGA : 314.90, A(Er): 160.89 (1:0.003, 2:72.16, 3:88.73), Er (%): 51.09, Sp.P: Drought, erosion, landslide**			
	Existing cropping system: maize-wheat/mustard/cole crops **Possible cropping and inter cropping system :** Rice–cowpea/green gram/black gram, rice-vegetables/pulses/sunflower/ sesamum, Jowar–oilseed/pulses Inter cropping of arhar + groundnut (2:5), arhar + sesamun (2:4), maize + cowpea (2:2)	Green gram and cow pea as cover crop for soil fertility improvement *Gliricidia* as green manuring crop on the field bund	Horticulture crops: Pine apple, mandarin orange, citrus. tea, ginger, chilly, large cadamum.	Drought: In-situ rain water conservation measures like contour farming bunding, summer ploughing, intercultural practices, tillage practices may be followed.Weed control and un-bunded upland can be converted to bunded upland, water harvesting and recycling should be done. Life saving irrigation to crops.Erosion: Field bunding, stream bank protection works, and strengthening of embankments, construction of earthen and stone bunds, vegetative barrier. Landslide: construction of retaining wall, use of geo-jute for slope stabilization.

Table 4.4. Agro-forestry solution for soil water conservation in West Bengal

S. No.	Agro Climatic zone	Area (000 ha)	Description	Agro-forestry system	Reference
1	Hill Zone	2024.1	Darjeeling excluding Siliguri subdivision and northern fringe of Jalpaiguri	Alnus nepalensis, *Albizia lebbek, Albizia procera, Senna siamea, Cassia pistula, Dalbergia sissoo, Dalbergia sericca, Melia azedarach, Terma orientails based agro-forestry system* ***Crops :*** *Cardamom, maize, green gram, sweet potato, yam, cow pea, beans* ***Crops taken during shade :*** *Ginger, turmeric, pine apple, black pepper, alovera, arrowroot*	Sharma et al., 2007; Chowdhury et al., 2015; ICFRE, 2020;Siril and Sarath, 2023
2	Terai Zone	1245.6	Coochbehar, plain of Jalpaiguri, Siliguri subdivision of Darjeeling part of West Dinajpur (Islampur subdivision)	*Albizia lebbek, Albizia procera,, Eucalyptus camaldulensis,* Elaeocarpus sphaericus, *Tectona grandis, Dalbergia sissoo, Melia azedarach, Shorea borneensis and Populus species based agro-forestry system* ***Crops:*** *Maize, potato, lentil, tea, sweet potato, yam, colocassia, cow pea, green gram, asparagus, citronella, palmarosa and mentha* ***Crops taken during shade :*** *Ginger, turmeric, pine apple, alovera, arrowroot*	Siril and Sarath, 2023; FRTC, 2019 ICFRE, 2020;
3	Old Alluvial Zone	1323.5	Malda, parts of West Dinajpur, Murshidabad	*Acacia mangium, Dalbergia sissoo, Neolamarkia cadamba, Gmelina arborea, Madhuca latifolia, Tectona grandis* and Populus deltoides *Scleichera oleosa* based agro-forestry system ***Crops:*** *Paddy, ladies finger, cow pea, maize,* ***Crops taken during shade:*** *Turmeric, pine apple, alovera, arrowroot*	ICFRE, 2020; Siril and Sarath, 2023;
4	New Alluvial Zone	1790.6	Nadia, Burdwan, North 24 Parganas, Hoogly. Western Murshidabad, Howrah.	*Acacia auriculoformis, Dysoxylum binectiferum, Eucalyptus teriticornias, Anthocephalus cadamba, Gmelina arborea, Tectona grandis* based agro-forestry system***Crops:*** *rice, maize, sesasum, pointed gourd, pea, cabage, cauliflower, brinjal, potato, pumpkin, okra, tomato, colocassia, mustard, linseed, lentil, elephant foot yam,* ***Crops taken during shade:*** *Turmeric, ginger, corriander , arrowroot*	Dhar et al., 2016 ICFRE, 2020;Siril and Sarath, 2023
5	Red and Laterite Zone	934.2	Purulia, Western Birbhum, Bankura	*Gmelina arborea, Eucalyptus teriticornias, Dysoxylum binectiferum, Bambusa balcooa, Tectona grandis* and *Bambusa strictus based agro-forestry system* ***Crops:*** *Maize, groundnut, pigeon pea, cow pea, bottle gourd, black gram, ladies finger, pumpkin, pea* ***Crops taken during shade:*** *Turmeric, pine apple, alovera, arrowroot*	Murmu et al., 2017;ICFRE, 2020;Siril and Sarath, 2023

6.	Coastal and Saline Zone	2335.6	South 24-Parganas and Medinipur	*Anthocephalus cadamba, Dysoxylum binectariferum, Eucalyptus tereticornis, Acacia leptocarpa, Shorea robusta, Madhuca indica, Azadirachta indica, Pongamia pinnata, Simarouba glauca, Gmelina arborea, Acacia auriculiformis, Ceiba pentandra, Anacardium occidentale, Mangifera indica based agro-forestry system* ***Crops:*** *Maize, groundnut, black gram, pigeon pea, cow pea, green gram, toria* ***Crops taken during shade:*** *Turmeric, alovera, arrowroot Mango+ Gamhar+Maize/groundnut, Mango + Eucalypatus + blackgram/okra, Gamhar + pigeon pea/cowpea/green gram/toria*	ICFRE, 2020;Siril and Sarath, 2023

5.0 CONCLUSION

Water induced soil erosion along with flood, land slide and cyclone are one of the major problems in West Bengal. The state is observed with 19.54% of the total geographical area under land degradation, out of which water erosion contributes 14.98%. Therefore, nearly 15% of the total geographical area need soil and water conservation treatments. The rest about 85% have erosion rate lower than the tolerance limit therefore no priority treatment is required, however, field level agronomic and vegetative measures are recommended for these lands also. Darjeeling is having the highest area i.e. 160.89 thousand ha of land in the need of SWC interventions followed by Purulia (59.73 thousand ha, and West Medinipore (41.50 thousand ha). The Darjeeling district is also having 72.16 thousand ha of area under high erosion risk (risk category 2) followed by Purulia (16.97 thousand ha) and West Medinipore (10.59 thousand ha).

In the state, mostly the erosion prone area is confined to Northern hill zone. In addition to soil erosion problem on arable and non-arable lands, associated special problems like degraded forest, landslides, sea water ingress, flood and drought etc. make the land treatment more challenging. A wide range of soil and water conservation measures including agronomic and vegetative measures for different land situations and agro-forestry measures for different districts and agro-climatic zones have been suggested. The suggested measures aim in reducing soil erosion below the soil loss tolerance limit of the area. The uniqueness of the present approach is that it integrates soil erosion risk areas with production losses of major crops, which would immensely benefit land use planners and policy makers to identify and prioritize the areas for execution of site specific best management practices and bring soil erosion rates within the permissible limits, thus saving on scarce financial resources.

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Agronomic conservation measures for arable lands

Rice- green manure crop sequence

Banana and vegetables in the rice field bunds

Intercropping of Zinger + Tomato+ Red gram

Relay cropping of Rice- black gram

Intercropping ofZInger and Lady finger

Intercropping of Colocasisa with maize

Agro-silvi AFS with Teak

Paired row Eucalyptus AFS

Shelter belt and windbreak with Silver oak trees

Mango AFS with Zinger

Homestead gardens

Relay AFS with Eucalyptus – Oil palm

Bio engineering (stonebunding+grass) measures

Paddy bund protection with local grass

Trench cum bunding with Pineapple barrier

Paddy cultivation in terraces

Trench-cum-Half moon basin

Geo jute cover with grass planting in mine spoiled area

Live check dam

Brush Wood Check Dam (BWCD)

Loose boulder check dam

Gabion check dam

Masonry check dam

Masonry diversion cum check dam

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