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








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29.03.2023

Message

I am delighted to comprehend that ICAR-Indian Institute of Soil and Water Conservation, Dehardun alongside with its Research Center-Vasad has prepared a technical document on Soil erosion status, priority treatment areas and conservation measures for different districts of Maharashtra. Soil erosion caused land degradation and productivity decline is one of the most leading distresses of Maharashtra despite the fact that the majority of Maharashtra falls under semi-arid tracts.

The chance of soil erosion in Maharashtra state is more serious in certain cases due to excessive rainfall at places, deforestation, and overgrazing and misguided land use practices led to abandonment of many lands. Besides this, the low and fluctuating farm profits are the major cause for decreasing the interest in farming. About 17.48% of the total geographical area of the Maharashtra requires distinctive levels of soil erosion management interventions. I am completely conscious of the fact that all the land under different forms of land degradation can no longer be handled in one go due to aid challenge and technical feasibility therefore, estimation of loss due to soil erosion and delineating priority areas through prioritization is essential to safeguards land resources of the state.

This document deal with a greater emphasis on district wise severity of soil erosion areas, soil erosion priority area of the state with distinctive priority classes and its extent, special problems and district wise engineering, agronomic, vegetative and agro-forestry measures. The details given in this document is easy to apprehend and prepared for ready to apply mode through the stakeholders throughout the state.

I congratulate the team of ICAR-IISWC, Dehradun and its Research Centre, Vasad for the tremendous efforts in compiling and bringing this document in the subject of imperative importance. I am sure, this document would be immensely beneficial to the executives, discipline functionaries and different stakeholders engaged in the dissemination of soil and water conservation and applied sciences in the watershed.

(S.K. Chaudhari)

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PREFACE

The ICAR-indian Institute of soil and water conservation (IISWC), Dehradun is one of the national Institute of Natural Resource Management Division (NRM) of the Indian Council of Agricultural Research, Ministry of Agriculture and Farmer's Welfare, Government of India. The institute alongwith its eight research centers is continuously working for development of location specific cost-effective soil and water conservation technologies, imparting training to state government officials and developing model watersheds as a learning sites for further adoption and upscaling in the field of soil and water conservation technologies and watershed management. The Research Centre (RC)-Vasad located in Gujarat state is mandated to develop land reclamation technologies for ravine infested gullied land along the river banks in Gujarat and Maharashtra.

The background of development of this document on "Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of Maharashtra" lies in the deliberations and subsequent recommendations of the Research Advisory Committee (RAC) of the institute. The committee stressed on developing strategy for arresting soil erosion and priority for sustainable development of the Western region. On the recommendations and subsequent suggestions of the committee, a team comprising members from the Research Centre Vasad was formulated at the institute.

As per the estimations of the institute about, about 17.48% of the total geographical area (TGA) of the Maharashtra experience is moderate and moderate to severe soil erosion loss due to water erosion thereby leading to an annual production loss of 15% alone in rainfed cereal, oilseeds and pulse crops. Such degradation of land due to various forms of soil erosion leads to decrease in the land productivity, economic losses propels the risk to local food supply system and livelihoods. The recently released IPCC's Sixth Assessment Report (AR6, 2021) (Maason et al., 2021) predicts increase in the heat waves, droughts, rainfall events and a likelihood of more cyclonic activity for India and the subcontinent over the coming decades. The prediction of more severe rains over Western India in the coming decades further underscores the requirement of 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. The document contains soil erosion status and erosion induced losses including production and monetary losses at national level as well as for the Maharashtra state. Besides, priority map, area under various degrees of risk and district specific agronomic, vegetative and engineering soil and water conservation (SWC) measures have also been presented in details. The list of location specific soil and water conservation and agroforestry measures for each district has been compiled as a ready reckoner for policy makers, researchers, planners, NGO's and extension functionaries working to address the various forms of land degradation problems.

(Authors)

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1.0. INTRODUCTION

Soil erosion is one of the most serious environmental concerns affecting all natural and human-managed ecosystems. Soil erosion, besides having significant impact on productivity of cultivated land also adversely affects chemical, physical and biological functions of soil leading to soil degradation and depletion of multiple soil functions. Although soil erosion is a global phenomenon, it has intensified in recent years due to population pressures, developmental activities, and unscientific land use and land management practices (Bawa, 2017). The risk of soil erosion in Maharashtra is more serious as many lands can no longer be sustained for production, mainly due to high intensity rainfall, deforestation, overgrazing and faulty land use practices thus leading to their abandonment (Singh et al, 2020).

Maharashtra is situated between 15°44′ to 21°40′ N latitudes and 73°15′ to 80°33′ E longitudes, covering 30.76 M ha (307,713 km^2). It is bounded by Gujarat and Dadra and Nagar Haveli in the North-West; Madhya Pradesh in the North, Andhra Pradesh and Karnataka in the South-West, Goa in the South and Arabian Sea in the West. The state is divided into Western Konkan coast, Western Ghats (North Sahyadris) and North Deccan plateau. The Western Konkan coast is a narrow coastal strip on the Western part of the Sahyadris with longitudinal distance of 500 km and a width of 15-20 km. The northern part of the strip covering Thane and Raigad are relatively flat with gently sloping residual hill tops of lateritic exposures. Kalyan, Ulhasnagar and Karjat are in plains with some spurs of Western Ghats such as Matheran hills that attain a height of 700 m above Mean Sea Level (MSL). Western Ghats (North Sahyadris), commonly known as Sahyadris, form Western edge of the Deccan plateau with several basaltic lava flows of the height of 1,500 m at places. This chain of mountains extends from South of the Tapi in Gujarat to the tip of Peninsula and forms a physical and cultural barrier between plateau and coastal lowlands. The western edge of the plateau ends abruptly with an escarpment of 600 m height above MSL, descending to the coastal lowland of Konkan. These mountains have a crest zone of 15 to 25 km width with dissected hill ranges of precipitous slopes and narrow steep sided valleys. It has also many peaks of varying heights ranging from 901 m (Pondaghat peak) to 1,646 m (Kalsubai peak). North Deccan (Maharashtra plateau) towards the East of Sahyadris is divided into Upper Maharashtra (Deccan) plateau, Lower Maharashtra (Deccan) plateau and Lower Maharashtra plateau (Metamorphic). Upper Maharashtra (Deccan) plateau stretches South East and is interspersed with hill ranges like Mahadeva and Ajanta and with mesas and buttes and broad valleys in-between. It has gently sloping to very gently sloping plains. The broad valley lies in between Ajanta and Mahadeva plateaux with eroded pediment, followed by depositional piedmont merging to flood plains of the Godavari, Bhima and Krishna rivers. Lower Maharashtra (Deccan) plateau lies in the East of the upper plateau. It has vast plains formed downstream mainly due to the Godavari, Bhima and Krishna rivers. The plains have

undulating to rolling lands merging to valleys of flood-plain regions. Lower Maharashtra plateau (Metamorphic) is exposed all along the Wainganga valley. In Penganga valley, beds consist of quartzites and coal beds of lower Gondwana. Nagpur forms Eastern most extension of the plateau.

The geological formations include Deccan Trap with intertrappen beds of Cretaceous-Ecocene period, Lameta beds of Upper Cretaceous period, Gondwanas of Upper Triassic period, Middle Jurassic and Upper Carbonaceous period, Vindhyan system, Penganga beds and Kaladgi series of Upper Precambarian and Dharwar system, Sausar and Sakoli series of Lower Precambarian times. Maharashtra, in general, is a plateau which is sloping gently towards Eastern side of the state. The elevation of the state ranges from 150 to 400 m above MSL. The Sahyadris have a coastline of about 1,500 m above MSL and have a width of 15-25 km running from North to South.

The state has sub-tropical monsoonic climate of humid-per-humid, semi-arid and sub-humid type. The rainy season is mostly confined to South-West monsoon, of which 80% is received during June-October. The Western part of the Sahyadris and Konkan coast receives 2,500-4,000 mm rainfall and has marine humid-per-humid climate with more humidity and less diurnal variations. Sahyadris receive highest rainfall of about 4,000 to 6,000 mm. The crest line receives more than 7,000 mm of rainfall. The mean annual temperature ranges from 25° to 28°C, the highest (46°C) being in May and the lowest is (11°C) in December. The mean maximum temperature of the hottest month in Konkan is 32.7°C. At Nasik, Pune, Kolhapur, it is less than 40°C, while in Central and Eastern parts, it ranges from 40° to 46°C. The mean minimum temperature of coldest month in the Western coast varies from 16° to 29°C, and it ranges from 11° to 15°C in the Central, Eastern parts of the state. Owing to coastal climate, diurnal and monthly temperature variations in a year in the coast are low as compared to plateau areas.

Forests in the state occupying 6.6 M ha (17%) of the TGA and are distributed in the Western, Northern and Eastern zones that receive relatively heavy rainfalls. Four types of the forests are: tropical evergreen forests, tropical moist deciduous forests, tropical dry deciduous forests and tropical thorny forests. Jamun (*Syzygium cumini*), Pista (*Actinodaphne angustifolia*), Anjani (*Memecylon umbellatum*), Hirda (*Terminalia chebula*), Teak (*Tectona grandis*), Arjun (*Terminalia arjuna*), Haldu (*Adina cordifolia*), Tiwas (*Ougeinia dalbergioides*), Khair (*Acacia catechu*), Shivan (*Gmelina arborea*), Dhavada (*Anogeissus latifolia*), Salai (*Boswellia serrata*), Babul (*Acacia nilotica*), Ber (*Zizyphus jujuba*), Palas (*Butea monosperma*) are common species found in the forest areas (Jinger et al., 2023). Littoral forests have Casuarina and mangroves.

Soils of the state belong to major 5 orders and 8 great groups. Entisols (37%),

Inceptisols (31%), and Vertisols (26%) are the predominant soils, followed by Alfisols (6%) and Mollisols (<1%). The different great groups are: Rhodustalfs, Haplustalfs, Haplustoll, Ustifluvents, Ustorthents, Halaquepts, Ustropepts, and Chromusterts (Challa et al., 1995).

Out of the total geographical area in the state, 58% of the land is under cultivation and the remaining is either covered with forest or scrub vegetation or left as culturable waste; 12% of the cultivated area is irrigated. Cropping pattern includes rice-wheat, rice-mustard and rice-chickpea. Cotton is grown in Vidarbha. Sugarcane is grown in Western Maharashtra. Presently soybean has been adopted as a cash crop by many farmers. Nashik and Pune districts are famous for vegetables, onion and grape production (ICAR, 2010).

Soil erosion coupled with soil acidity is a major problem in Western Maharashtra, and soil erosion is a major problem in Vidarbha region. In this state, about 8,822 thousand ha (about 29% of TGA) is affected by water erosion including erosion under open forest. Highly affected districts are Nashik (836 thousand ha), Ahmednagar (806 thousand ha), Pune (788 thousand ha), Solapur (683 thousand ha), Sangli (616 thousand ha), Raigad (570 thousand ha), and Ratnagiri (543 thousand ha) (ICAR, 2010).

Total area under acidic soils (including areas affected by water erosion) covers 269 thousand ha. The Sindhudurg district has an area of 172 thousand ha, followed by Ratnagiri (64 thousand ha) and Kolhapur (21 thousand ha). Highest areas under sodic soils are found in Ahmednagar district (265 thousand ha). Other affected districts are Nashik (40 thousand ha), Aurangabad (31 thousand ha), Pune (26 thousand ha) and Solapur (20 thousand ha) (ICAR, 2010).

In an agrarian country like India, assessment of soil erosion risk is of paramount importance to preserve soil's productive potential and ensure sustainable land use (Mandal and Giri, 2021, Sharda and Mandal, 2018). Land managers and policy makers need to have adequate knowledge of intensity and distribution of soil erosion risk areas to check land degradation, and efficiently plan and execute various cost-effective land-based interventions to achieve the targets of Land Degradation Neutrality (LDN) (UNCCD, 2016). Hence, it is imperative to quantify the risks associated with overuse of soil functions, which leads to land degradation and consequently impacting on eco-system services.

2.0. LAND DEGRADATION THROUGH SOIL EROSION AND ITS IMPACTS

2.1. Land Degradation: In India, about 120.7 million ha area, which includes arable and non-arable lands, is subjected to various forms of land degradation (ICAR, 2010), with maximum (82.6 million ha, 68.4%) contribution by water erosion (49% area accounts for soil loss >10.0 t ha^{-1} yr^{-1}). The soil erosion and other associated losses is presented in (Fig.2.1).

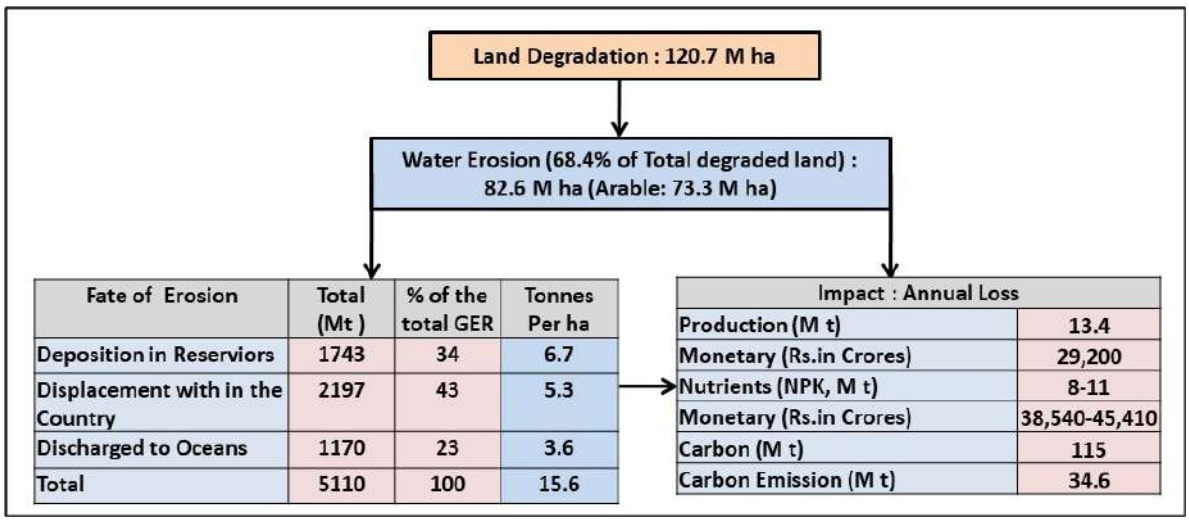
2.2. Gross Erosion Rate: The gross annual soil erosion of our country is 5.11 billion tonnes out of which 34.1% deposited in the reservoirs, 22.9% is discharged outside the country (mainly to oceans), and 43.0% is displaced within the mainland (Sharda and Ojasvi, 2016). Average annual reduction in water storage capacity of dams by 1.2% (data from 4937 big dams) and average life span reduction of dams by 25 years (Range 8-53 yrs) due to sedimentation of the reservoirs.

2.3. Production Loss & Monetary Loss: 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 million tonnes (Sharda et al., 2010) valued at ₹. 29200 crore during 2015-16 (Sharda and Dogra, 2013).

2.4. Nutrients Loss: A significant amount (8 to 11 million tonnes of NPK) of nutrients gets transported with runoff and eroded soil leading to net loss of ecosystem services. Soil loss resulting due to water erosion in India leads to 5.37 to 8.40 million tonnes of nutrients loss from the soil (Sharda and Ojasvi, 2016). The nutrient loss due to water erosion estimated as monetary loss of ₹. 38,540 to ₹. 45,410 crores annually at market price of 2020. Further the estimated erosion linked loss of N, P, K, and S due to displacement of nutrient from the soil due to water ersoion is 4.41-9.61, 0.387-2.31, 4.43 and 1.27-1.65 million tonnes amounting to the corresponding monetary loss of ₹. 13500-29300, ₹. 1850-8320, ₹. 17300 and ₹. 5890-7790 crore rupees at market price of 2020, respectively.

2.5. Carbon Loss: Release of extra carbon dioxide into the atmosphere by organic matter dislodgement followed by decomposition has serious implications on climate change. The soil pool loses of 1100 million tonnes of C into the atmosphere as a result of soil erosion and another 300-800 million tonnes of C annually to the ocean (Lal, 2011). The quantity of organic C displacement due to water erosion in India is about 115 million toones yr^{-1} which consequently emits about 34.6 million tonnes of C to the atmosphere; erosion control can reduce C emission by 19.0-27.0 million tonnes per year (Mandal et al., 2020).

2.6. Loss in Reservoir Capacity: The total sediment trapped in the reservoirs with a total gross capacity of 299.5 G m^3 was estimated at 1679 M m^3 yr^{-1}, as a result of which the average annual capacity loss of the reservoirs was calculated as 1.04% with a range of 0.47 to 3.05% (Sharda and Ojasvi, 2016). Loss of gross storage capacity in the range of 0.50% to 0.80 % per year is experienced in the case of larger dams with capacity varying from 51 to >1000 M m^3. Smaller dams of 1 to 50 M m^3 capacity experience a reduction in storage capacity ranging from 0.80% to > 2.00% per year. The annual total storage loss and dead storage loss in Sardar Sarovar dam has been estimated to be 0.495% and 1.27%, respectively resulting to annual capitalized loss of 1070 to 1137 million rupees for loss in power generation and irrigated area under different scenario of rainfall (Pande et al., 2014).



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)

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. The quantity of soil erosion per year in Maharashtra is 773.5 million tonnes, and 94% of that erosion is water induced. The detrimental effects of soil erosion are reflected in the land's declining productivity.

The district wise prioritisation/risk area was assessed from the data base on potential soil erosion rates and soil loss tolerance limits for the state of Maharashtra. 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 5 and 35 t ha^{-1} yr^{-1} (Class 1: > 35 t ha^{-1} yr^{-1}, Class 2: 25-35 t ha^{-1} yr^{-1}, Class 3: 15-25 t ha^{-1} yr^{-1}, Class 4: 5-15 t ha^{-1} yr^{-1}, 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 Maharashtra state an area of great concern from soil erosion point of view. For 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.

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 districts of Maharashtra and the proposed conservation measures for each district are aimed to reduce soil erosion below the soil loss tolerance limit.

4.0. EROSION STATUS AND CONSERVATION PLANNING FOR THE STATE OF MAHARASHTRA

4.1. About the State: Maharashtra is located in Western part of Central region of India covering TGA of 30.77 M ha. The state has three principal physiographic regions, namely coastal Konkan, Western Maharashtra, Marathwada, and Vidarbha. The average annual rainfall in the state is 1,181 mm and 75 per cent of it is received during the South-West monsoon from June to September. Thane, Raigad, Ratnagiri, and Sindhudurg districts receive heavy rains of an average of 2,000 to 2,500 mm and the hill stations of Matheran and Mahabaleshwar over 5,000 mm. However, the rain shadow districts of Nashik, Pune, Ahmednagar, Dhule, Jalgaon, Satara, Sangli, Solapur, and parts of Kolhapur receive less than 1,000 mm annually. Maharashtra experiences a tropical monsoon climate with hot, rainy, and cold weather seasons and dry summers. In the Central plains, summer temperatures rise between 40 °C to 45 °C (Singh et al., 2019).

4.2. Soil Erosion Rate: Analysis of soil erosion data revealed that soil erosion rates vary enormously across the state, ranging from less than 5 t ha^{-1} yr^{-1} in 0.01% area to very severe (> 40 t ha^{-1} yr^{-1}) in 36.04% area. Percentage of area under slight (<10 t ha^{-1} yr^{-1}), moderate (10-20 t ha^{-1} yr^{-1}) and severe (20-40 t ha^{-1} yr^{-1}) soil erosion classes are 3.01, 8.16 and 6.29, respectively. Analysis of the data also revealed that nearly 17.48% area across the state has erosion rates of more than 10 t ha^{-1} yr^{-1}, which indicates that soil erosion is a serious problem in major parts of the state. The severity of soil erosion is due to aggressive climatic conditions coupled with steep topography and erodible soils (Kumar et al., 2021).

4.3. Soil Loss Tolerance Limit (SLTL): Data pertaining to soil loss/erosion tolerance limits indicated that it varies between 4.5 and 11.2 t ha^{-1} yr^{-1} (Mannering, 1981). The areas having lower T-values ranging from 4.5 to 11.2 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. 4.1).

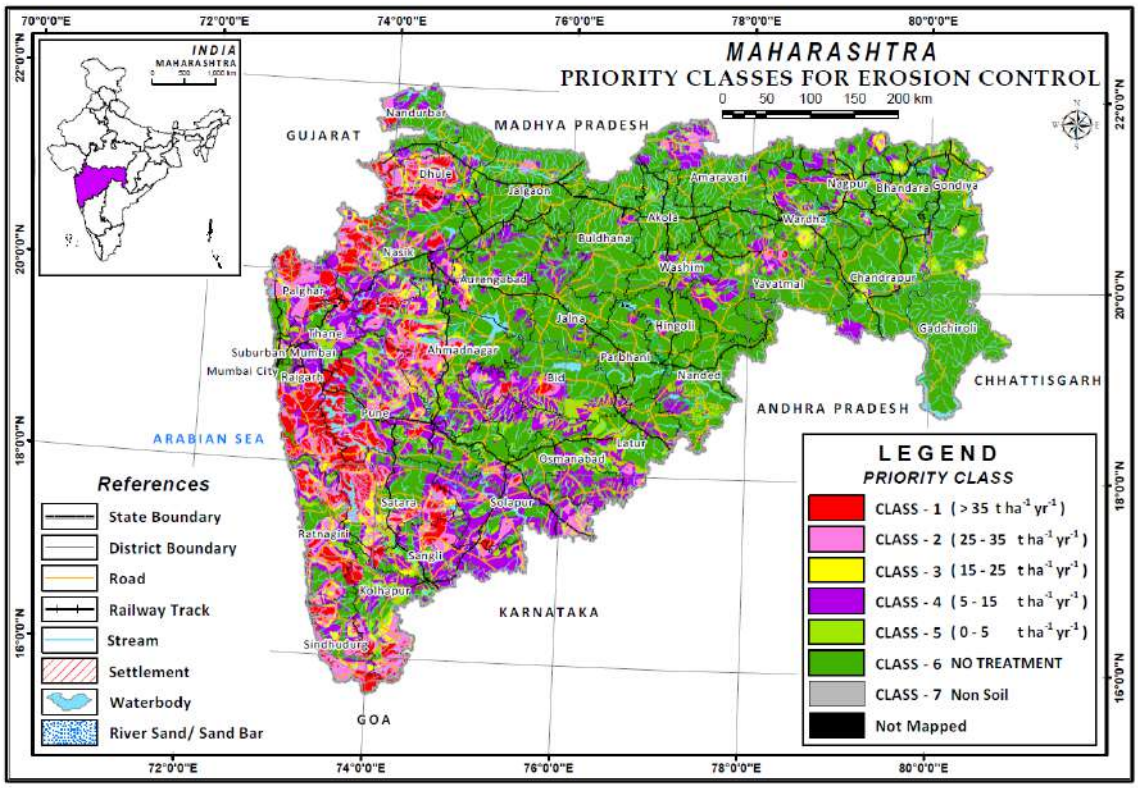


Fig. 4.1: Priority classes for erosion control in Maharashtra state

4.4. Production and Monetary Loss from Rainfed Crops due to Soil Erosion

The average production loss of cereal and millets, oilseed and pulse crops were estimated to be 14%, 17% and 15%, respectively, and consequently, average loss considering cereals, oil seeds and pulses together is about 15%. Out of 1.60 million tonnes, total production losses, 60.2% is due to losses in cereals and millets, 25.9% in oilseeds and 13.9% in pulses (Fig. 4.2). In terms of monetary losses, 41.1% of the total loss of ₹. 47,653 million occurs in Maharashtra due to production losses in cereals and millets, followed by 32.7% in oilseeds, and 26.2% in pulses (Fig. 4.3). The largest contribution is from soybean (23%) followed by sorghum (15%), and paddy (12%) (Rao et al., 2022).

The productivity losses of cereal and millets, oilseed and pulse crops were estimated to be 127 kg ha^{-1}, 138 kg ha^{-1} and 72 kg ha^{-1}, respectively. The average productivity loss of all these crops together is 117 kg ha^{-1} (Sharda and Dogra, 2013), which in monetary terms was ₹.3484 ha^{-1} during 2018-19 (Fig. 4.4). The Gross State Domestic Product (GSDP) of Maharashtra for 2018-19 at current prices was estimated to be ₹. 27,96,086 crore at prices for year 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 0.17% of its GSDP during 2018-19.

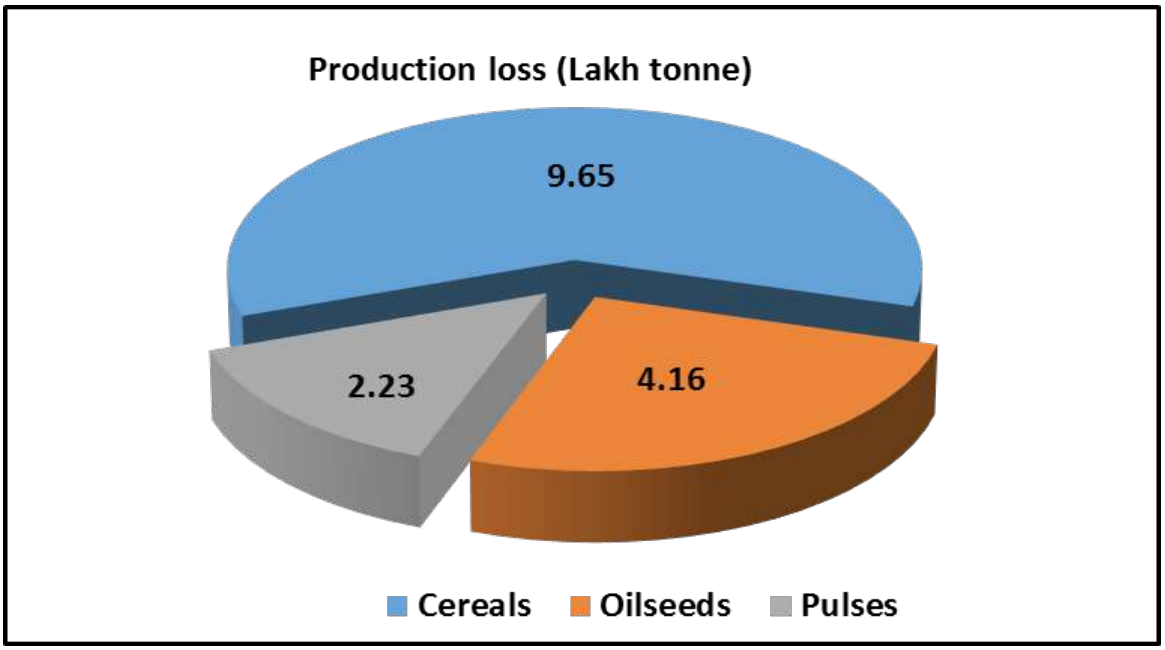


Fig. 4.2 Estimated total production loss of rainfed crops due to soil erosion in Maharashtra State

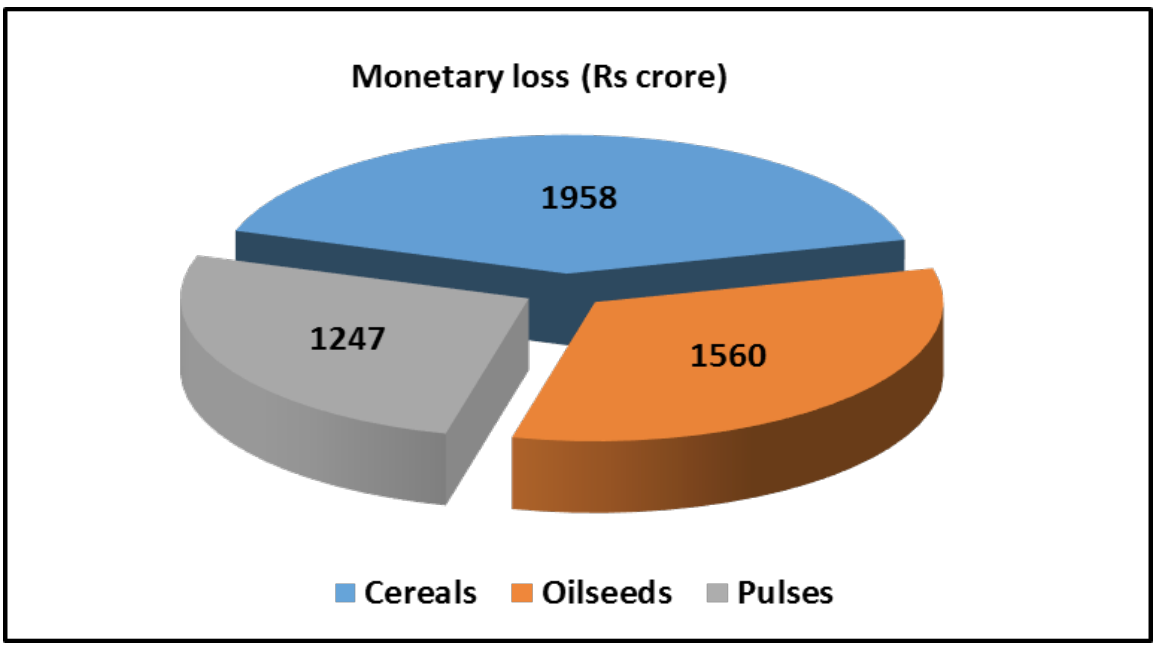


Fig. 4.3. Estimated total monetary loss of rainfed crops due to soil erosion in Maharashtra State

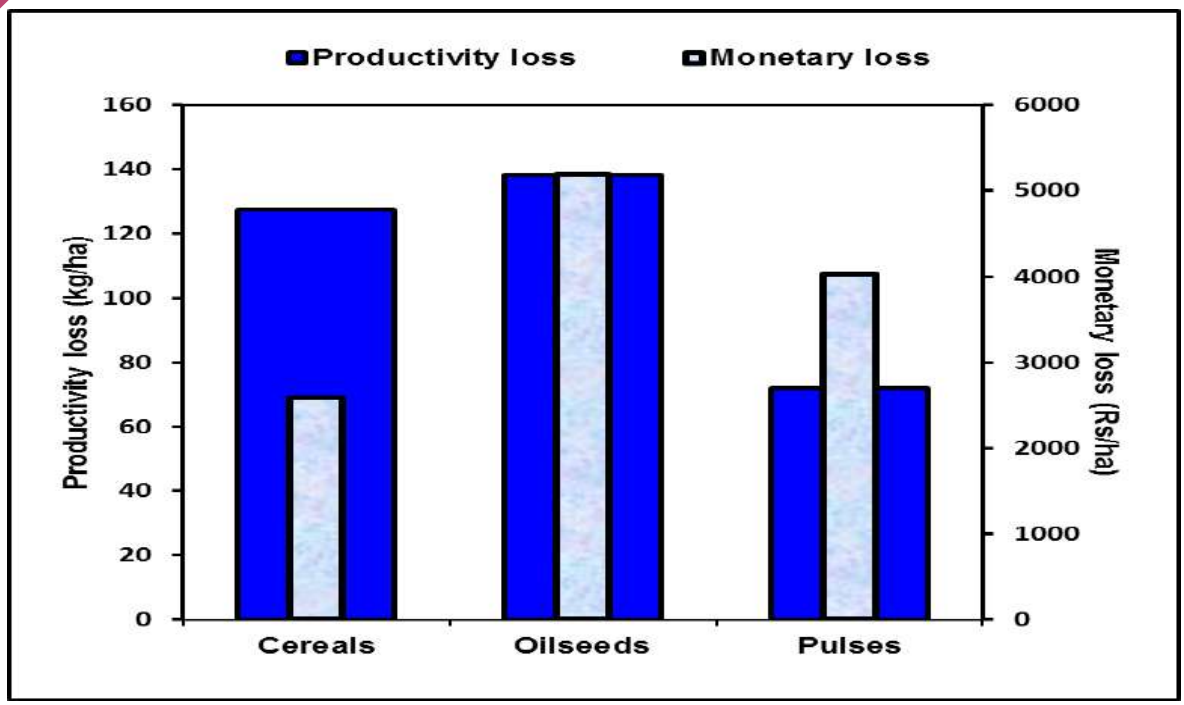


Fig. 4.4. Estimated productivity (kg ha^{-1}) and monetary loss (₹. ha^{-1}) of rainfed crops due to soil erosion in Maharashtra State

4.5. Area under Risk: It is evident that 17.48% of TGA of the state requires different degrees of soil erosion management and only 82.52% of TGA falls under no treatment category in view of the fact that soil loss is within permissible soil erosion limits. Though 14.46% area of the state falls under severe and very severe soil erosion categories, 43.93% has high priority from conservation point of view with a T-value upto 7.5 t ha^{-1} yr^{-1} (Fig 4.1). Similarly, though 16.08% area has prevailing soil erosion rates of less than 10 t ha^{-1} yr^{-1} but 60.19% area still falls under priority classes 4 and 5 requiring less degree of conservation treatment. Delineating critical land degradation areas through prioritization process is crucial for developing open-space plans that protect 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 (Table 4.2), (Table 4.3) and (Table 4.4) which are given in the succeeding sections of the document. (Table 4.2) which presents soil and water conservation engineering measures, under different land situations, (Table 4.3) presents district wise agronomic and vegetative measures and (Table 4.4) presents district wise agroforestry measures.

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

		Area in 000'ha				
S. No.	**District**	**TGA**	**Area under risk**	**% of TGA**	**Special erosion problem**	**Conservation measures**
	Severity of risk-No risk					
1	Mumbai City	7.51	0.00	0.00	Urbanization, flash floods	Table 4.2 - Sr. No 3.2.1, 3.1.1, 6.1.1, 3.2.3, 3.2.1, 6.2.3, 4.6, 4.4. Table 4.3 - Sr. No. 01
2	Washim	512.77	0.00	0.00	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1, 6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 08
3	Akola	541.04	0.00	0.00	Saline soil	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 08
4	Parbhani	612.86	0.00	0.00	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 07
5	Jalna	766.56	0.00	0.00	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 07
	Total	**2440.74**	**0.00**	**0.00**		

	Severity of risk-A					
6	Buldhana	972.17	0.04 (1:0.02, 2:0.02)	0.004	Saline soils	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 Sr. No. 08
7	Nanded	1061.02	0.58 (1:031, 2:0.18, 3:0.09)	0.05	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 07
8	Hingoli	488.67	0.97(2:0.97)	0.20	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 07
9	Chandrapur	1130.15	12.09 (1:0.11, 2:0.65, 3:11.33)	1.07	Gully erosion, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 08
10	Osmanabad	760.22	12.31 (2:8.80, 3:3.51)	1.62	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3- Sr. No. 07
11	Suburban Mumbai	44.05	13.64 (2:3.13, 3:10.51)	30.96	Urbanization, flash floods	Table 4.2 - Sr. No 3.2.1, 3.1.1, 3.3.1, 6.1.1, 3.2.3, 3.2.1, 6.2.3, 4.6, 4.4. Table 4.3 - Sr. No. 01
12	Latur	723.48	18.35 (2:17.66, 3:0.68)	2.54	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 07

13	Bhandara	400.48	19.13 (1:1.07, 2:8.63, 3:9.44)	4.78	Gully erosion, Mining	Table 4.2 - Sr. No. 6.1.1 -6.1.9, 6.2.1-6.2.12 Table 4.3 - Sr. No. 09
14	Jalgaon	1174.69	22.00 (1:0.01, 2:17.03, 3:4.96)	1.87	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 06
15	Wardha	628.59	23.64 (2:3.41, 3:20.23)	3.76	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 08
16	Gondiya	527.19	25.47 (2:5.51, 3:19.96)	4.83	Gully erosion, Mining	Table 4.2 - Sr. No. 6.1.1 -6.1.9, 6.2.1-6.2.12 Table 4.3 - Sr. No. 09
17	Nagpur	984.63	33.47 (1:0.01, 2:11.92, 3:21.53)	3.40	Gully erosion, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 09
18	Gadchiroli	1449.06	40.17 (2:6.42, 3: 33.74)	2.77	Gully erosion	Table 4.2 - Sr. No. 6.1.1 -6.1.9, 6.2.1-6.2.12 Table 4.3 - Sr. No. 09
19	Yavatmal	1354.32	41.05 (1:5.33, 2:25.87, 3:9.84)	3.03	Gully erosion, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 08
	Total	**11698.73**	**262.92**	**2.25**		

	Severity of risk-B					
20	Aurangabad	1014.86	58.64 (1:4.37, 2:26.19, 3:28.08)	5.78	Gully erosion and sodic soils	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 07
21	Thane	426.29	63.22 (1:16.86, 2:43.26, 3:3.10)	14.83	Water logging, Mining, saline and sodic soils	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 01
22	Amaravati	1215.63	63.31 (1:0.11, 2:50.64, 3:12.56)	5.21	Gully erosion, Saline and sodic soils, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 08
23	Bid	1061.43	95.37 (1:35.58, 2:52.38, 3:7.41)	8.98	Gully erosion	Table 4.2 - Sr. No. 2.1, 2.2, 2.4, 2.5 3.1.1, 3.2.3, 3.2.1-3.2.4, 3.2.6, 4.1-4.6, 4.8, 4.9, 5.1-5.7, 6.1.1-6.1.4, 6.1.6-6.1.8, 7.1-7.10 Table 4.3 - Sr. No. 07
	Total	**3718.21**	**280.54**	**7.54**		
	Severity of risk-C					
24	Nandurbar	586.64	125.57 (1:45.76, 2:57.60, 3:22.22)	21.41	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 04
25	Solapur	1493.64	208.75 (1:19.31, 2:145.17, 3:44.27)	13.98	Gully erosion, sodic and eroded sodic soils	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 06

26	Sangli	869.51	214.19 (1:63.95, 2:105.47, 3:44.76)	24.63	Gully erosion, Eroded sodic soils, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 06
27	Dhule	715.12	292.46 (1:97.70, 2:144.48, 3:50.27)	40.90	Gully erosion	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 06
28	Kolhapur	777.27	295.94 (1:86.60, 2:167.48, 3:41.86)	38.08	Gully erosion, sodic and eroded sodic soils, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 04
29	Sindhudurg	512.59	307.46 (1:106.80, 2:156.55, 3:44.11)	59.98	Gully erosion, Acid soils, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 03
30	Palghar	526.70	344.35 (1:141.52, 2:187.43, 3:15.41)	65.38	Gully erosion	Table 4.2 - Sr. No. 2.1, 2.2, 2.4, 2.5 3.1.1, 3.2.3, 3.2.1, 3.2.4, 3.2.6, 4.1-4.6, 4.8, 4.9, 5.1-5.7, 6.1.9-6.1.9, 6.2.1-6.2.6, 6.2.11, 6.2.12, 7.1, 7.7, 7.8 Table 4.3 - Sr. No. 01
31	Ratnagiri	829.65	417.86 (1:141.69, 2:200.91, 3:75.27)	50.37	Gully erosion, Acid soils, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 02

32	Ahmadnagar	1710.50	492.85 (1:141.25, 2:242.04, 3:109.56)	28.81	Gully erosion, Sodic and Eroded sodic soil	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 03
33	Satara	1053.30	506.48 (1:176.29, 2:211.61, 3:118.58)	48.09	Gully erosion, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 03
34	Raigarh	723.59	518.01 (3:338.18, 2:159.24, 3:20.59)	71.59	Gully erosion, Mining	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 01
35	Pune	1568.61	533.91 (2:272.69, 2:203.35, 3:57.87)	34.04	Gully erosion, sodic and eroded sodic soils	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 04
36	Nasik	1546.49	576.36 (2:242.56, 2:248.39, 3:85.41)	37.27	Gully erosion, sodic and eroded sodic soils	Table 4.2 - Sr. No. 2.1- 2.5, 3.1.1, 3.1.2, 3.2.2-3.2.6, 4.2-4.6, 4.8, 4.9, 5.3- 5.7, 6.1.1-6.1.9, 6.2.1-6.2.12, 7.4, 7.5, 7.7, 7.8, Table 4.3 - Sr. No. 04
	Total	**12913.62**	**4834.21**	**37.43**		

Note : Severity risk - No risk: Area under (Er-T) > 15 t ha^{-1} yr^{-1} is nil however some area having more than 10 t ha^{-1} yr^{-1} need to be treated. 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, 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. (Er – TL); 1: (Er –TL) >35 t ha^{-1} yr^{-1}, 2: (Er – TL) in the range of 25-35 t ha^{-1} yr^{-1}, 3: (Er – TL) in the range of 15-25 t ha^{-1} yr^{-1}. (Table 4.2) represents different soil and water conservation engineering measures for different land situations, (Table 4.3) presents agronomic and vegetative measures and (Table 4.4) represents district wise potential agro-forestry system (AFS).

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

S. No.		Conservation Measures	Slope <10% Low priority class		Slope-10-33% High priority class	
			Arable land	Non arable land	Arable land	Non arable land
1.0	**Agronomic Measures (upto 6%, agronomic measures alone; >6% with other land management practices)**					
	1.1	Contour cultivation/farming	√		√	
	1.2	Inter or mixed cropping	√		√	
	1.3	Green manuring & Recycling crop residues	√		√	
	1.4	Crop rotation	√		√	
	1.5	Mulching	√		√	
	1.6	Conservation tillage/Conservation agriculture	√		√	
	1.7	Cover crops	√		√	
	1.8	Medicinal and aromatic crop cultivation	√		√	
	1.9	Broad bed and furrow (Black soil)	√			
	1.10	Furrow opening in between the lines (Black soil)	√			
	1.11	Cutivation of fodder grasses	√		√	
	1.12	Sand treatment for improvement of soil texture and soil physical properties	√		√	
	1.13	Bio-drainage or sub-surface drainage system	√		√	
2.0	**Vegetative measures (At lower slope-alone, at higher slope with other conservation measures**					
	2.1	Vegetative barrier*/Mixed vegetative barriers*	√	√	√	√
	2.2	Afforestation/reforestation		√		√
	2.3	Grassed waterways	√	√	√	√
	2.4	Live vegetative check dam with different species along with Bamboo		√		√
	2.5	Stream bank stabilization with bamboo and other species		√		√
		**Species:* Vetivera grass *(Vetiveria zinanoides)* ; Lemon grass *(Cymbopogon citrates);* Rosa/ palma rosa grass *(C. martinii);* Malabar *(C. flexuosus);* Hybrid Napier*;* Agave *(Agave Americana & Agave sisalana);;* Mulberry *(Morus alba);* Para grass *(Panicum maximum),* Marvel grass *(Dicantum anuulatum),* Buffel grass *(Cenchrus ciliaris*), Indian Tree of Heaven (*Ailanthus excelsa*), Malabar neem (*Melia dubia*), Babul (*Acacia nilotica*).				
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 (Where stones are available onsite)	√	√	√	√

	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			√	
	3.3.8	Conservation Ditch		√		√
4.0	**Drainage Line Treatments (DLT's)**					
	4.1	Earthen Check dam		√		
	4.2	Sandbag check dam		√		
	4.3	Brush wood check dam (BWCD)		√		√
	4.4	Loose boulders check dam (LBCD)		√		√
	4.5	Gabion check dam		√		√
	4.6	Plastic head wall composite check dam/Masonary 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 & Desilting	√	√	√	
	5.4	Dugout type farm pond	√		√	
	5.5	Sub surface water harvesting structures (Dykes) with sub-surface 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**					
	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 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 bunds/Stone bund		√		√
	6.2.2	Stone wall				√
	6.2.3	Staggered trenches and planting		√		√
	6.2.4	Loose Boulder check dam (locally available)				√
	6.2.5	Diversion drain/ Interceptor drain				√
	6.2.6	Nala bunds		√		
	6.2.7	Gabion check dam				√
	6.2.8	Gabion drop structures				√
	6.2.9	Toe drain for seepage control				√
	6.2.10	Retaining wall for slopes				√
	6.2.11	Jute geo textiles for slope stabilization/ Coir Jeo textiles for stabilization of slopy lands (Slope >33%)				√
	6.2.12	Stream Channelization (Retaining wall, Bank protection walls. Spurs with apron etc)		√		√
7.0	**Gullied Land**					
	7.1	Bio fencing/social fencing		√		√
	7.2	Safe disposal of water from gully head-Piped/chute spillway-		√		√
	7.3	Alternate land use system/Agroforestry		√		√
	7.4	Mechanical/Engineering measures		√		√
	7.5	Earthen check dam		√		√
	7.6	Boribund check dam		√		√
	7.7	Silt retention tank		√		√
	7.8	Staggered trenching + plantation		√		√
	7.9	Pre-fabricated drop structure on the gully head		√		√

Note 1: *District wise details of agronomic and vegetative measures for Maharashtra is given in (Table 4.3).*

Note 2: *For concept, design and estimates of soil and water conservation measures mentioned above. Kindly refer: Mishra, P.K., Jual, G.P., Tripathi, K.P., Ojasvi, P.R., Shrimali, S.S., Sena, D.R., Kumar, A., Patra, S. 2017. Field manual on soil and water conservation structures, ICAR, New Delhi, ISBN: 978-81-7164-167-3.*

Note 3: *For Agroforestry solution for soil water conservation in Maharashtra, Kindly refer (Table 4.4).*

Table 4.3 District wise area under various erosion risk and their possible agronomic and vegetative measures for Maharashtra

District Details: Name of District, Total Geographical area, TGA (000, ha), Area under erosion risk ('000 ha), Erosion risk area as a percentage of TGA, Special erosion problem				
Sr. No.	**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/ Pineapple etc.)**	**Special problem area: Grassed waterways/Live check dams/Mine spoil area/ Land Slide Prone Area**
	Severity of risk- No risk			
1	**Mumbai city, TGA: 7.51, A(Er): 0.0, Er (%): 0.0, Sp.P: urbanization flash floods**			
	Rice, Jowar, Mung, Wheat, Tur, Groundnut, Urad, Gram, and other pulses, Peanuts, Sunflowers, and Soybeans, Cotton, Sugarcane, Turmeric, Vegetables Scrambling and trailing vine-like plant (Water melon, Musk melon), Coconut, Mango	-	Coconut, Mangroves	Afforestation in open-pit mining areas. Slope treatment measures such as geo-jute matting with plantations.
2	**Washim, TGA: 512.8, A(Er): 0.0, Er (%): 0.0, Sp.P: Gully erosion**			
	Cotton Soybean Greengram Blackgram Pigeon pea Sorghum Cotton + Pigeon Pea Intercropping	Sunhemp and cluster bean for green manuring. Cowpea/Greengram/Blackgram for cover crop. Intercropping of Cotton + Pigeon pea for moisture conservation and crop insurance.	Planting of Berseem (*Egyptian clover*) around the bunds. Intercropping with Sesamum, Ragi, Groundnut, Castor Chillies, Cluster bean, etc., serve as an insurance against crop failure and as a preventive against soil erosion.	Protection and social fencing, Staggered trenches Prevention of forest and grass fire, Control of grazing

3	**Akola, TGA: 541.0 A(Er): 0.0, Er (%): 0.0, Sp.P: Salt affected lands**			
	Medium land deep clayey Black soils Bt. Cotton, Cotton + Pigeonpea, Soybean, Pigeonpea, Sorghum **Shallow loamy to clayey Black soils** Soybean, Greengram, Black gram	Greengram, Sunnhemp once in 4 year. Cowpea, Green-gram, Black-gram and Horse-gram as cover crop Conservation furrows, Frequent inter-cultivation for soil mulching Legume covers: *Hedge-Lucerne, Cassia tora, Hamata, Mucuna pruriens, Mimosa pudica, Tephrosia Purpurea, Leucaena leucocephala, Gliricidia maculate,* Green manuring: Lucerne in cotton crop Lucerne or Corchorus in Maize crop	Grasses: *Urochloa brizantha*, Fodder: Sorghum, Hybrid Napier, Guinea grass, Para grass, Herbs/Shrubs: *Stylosanthes hamata*, *M. atropurpureum*, Medicinal and aromatic: *Withania somnifera* *Zingiber officinale* *Aloe barbadensis Moringa oleifera* *Vetiver zizanioides* as vegetative barriers for moisture conservation.	Compartment bunding/ ridges and furrows/ Tied ridges to conserve the rain water during *kharif* for regular sowing of *rabi* crops. Ridges and furrows method of sowing. Cultivation of *Dendrocalamus strictus* or *Dendrocalamus stocksii*
4	**Parbhani, TGA: 612.9; A (Er): 0.0, Er (%): 0.0, Sp.P: gully erosion**			
	Medium deep to deep black soils Cotton + Pigeonpea 6:2 Sorghum + Pigeonpea 4:2 Soybean+ Pigeon pea 4:2	Interculture for weeding and to create soil mulch. Protective irrigation wherever possible.	Grasses: *Urochloa brizantha*, Fodder: Sorghum, Hybrid Napier, Guinea grass, Para grass,	Block plantation & community land afforestation - Raising of forest tree and plantations (Teak, Neem and Glyricidia) on lands which were not covered with forest and were reduced to scrub due to biotic interference.

	Green Gram, Pigeon pea, Black gram **Shallow soils** Cotton , Sorghum, Soybean, Green gram, Pigeon pea, Black gram	Making of conservation furrows for moisture conservation. Interculture with harrow when the crop is 2 weeks old.	Herbs/Shrubs: *Stylosanthes hamata*, *M. atropurpureum*, Medicinal/aromatic: *Withania somnifera* *Zingiber officinale* *Aloe barbadensis* *Moringa oleifera* *Vetiver zizanioides* as vegetative barriers for moisture conservation.	
5	**Jalna, TGA:766.6: A(Er): 0.0, Er (%): 0.0, Sp. P: Gully erosion**			
	Medium deep to deep black soils Cotton, Pearl millet, Maize, Pigeon pea, Green gram,- Sorghum/Safflower/ Chickpea , Soybean **Shallow soils** Cotton, Pearl millet, Maize, Pigeon pea, Green gram,-Sorghum/ safflower/ Chickpea , Soybean	Cowpea/Green gram/Blackgram for cover crop. Mulching in horticultural crop (Sweet orange). Inter cropping of Cotton + Pigeon pea and Safflower + Chickpea for moisture conservation and crop insurance.	*Leucaena leucocephala*, *Gliricidia sepium* & *Cymbopogon flexuosus* as vegetative barrier for moisture conservation and reduce runoff.	Growing of *Vetiver zizanioides*, and *Cenchrus ciliaris* as vegetative barrier to control runoff and soil loss in mine spoil area.

	TGA (000 ha): 2440.74: Area under Severity of risk: No risk: % of TGA under risk: 0			
	Severity of risk- No risk			
6	**Buldhana,TGA, 972.17, A(Er): 0.04 (1:0.02, 2:0.02), Er (%): 0.004, Sp. P: Salt affected lands**			
	Deep & Medium deep black soils Cotton Cotton + Pigeon pea Intercropping Soybean Green gram/ Black gram Pigeon pea Kharif Sorghum Cotton: sorghum: Pigeon pea: sorghum (6:1:2:1) **Shallow black soils** Soybean Green gram Black gram	Intercrop one row of pigeon pea after every 4 or 6 rows of soybean as per convenience. Open furrow after six /Three rows of soybean). Adopt closer spacing (60 x 30 cm) for pigeonpea. Follow *in-situ* moisture conservation measures. Weeding or inter-cultivation to create soil mulch to conserve moisture. Follow alternate row irrigation/ irrigate at critical stages	*Leucaena leucocephala*, *Gliricidia sepium* & *Cymbopogon flexuosus* as vegetative barrier	Growing of Dhaincha for reducing soil pH. Growing of salt tolerant fruit crops like coconut.
7	**Nanded, TGA, 1061.02, A (Er): 0.58 (1:031, 2:0.18, 3:0.09), Er (%): 0.05, Sp. P: Gully erosion**			
	Medium deep to deep and black soils Cotton Sorghum Soybean Black gram / Green gram Pigeonpea **Shallow black soils** Cotton Sorghum Soybean Black gram / Green gram Pigeon pea	Interculture for in-situ moisture conservation. Making of conservation furrows for moisture conservation when the crop is 2 weeks old take up Inter-culture with harrow. Spray 2% urea solution or 1% water soluble fertilizers like 19-19-19, 20-20-20, 21-21-21 to supplement nutrition. Sowing of Rabi crops like Sorghum, Chickpea, and Safflower immediately after harvest of Soy bean with minimum tillage.	Medicinal and Aromatic: *Withania somnifera* *Zingiber officinale* *Aloe barbadensis* *Moringa oleifera* *Vetiver zizanioides* as vegetative barriers for moisture conservation.	Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis*, *Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference

8	**Hingoli, TGA: 488.67: A(Er): 0.97(2:0.97), Er (%): 0.20, Sp.P: Gully erosion**			
	Medium deep to deep black soils Cotton Soybean Sorghum Pigeon pea Green gram **Shallow black soils** Cotton Soybean Sorghum Pigeon pea Sugarcane	Making of conservation furrows for moisture conservation. Sowing on broad bed furrow (BBF). Mulching with sugarcane trash between rows and frequent interculture to conserve moisture Spraying of 2% urea or DAP. Sowing of rabi crops like Sorghum, Chickpea, and Safflower immediately after harvest of Soy bean with minimum tillage.	Medicinal and aromatic: *Withania somnifera* *Zingiber officinale* *Aloe barbadensis* *Moringa oleifera* *Vetiver zizanioides* as vegetative barriers for moisture conservation.	Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis*, *Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference
9	**Chandrapur, TGA: 1130.15: A(Er): 12.09 (1:0.11, 2:0.65, 3:11.33) Er (%): 1.07, Sp.P: Gully erosion, Mining**			
	Medium deep to deep black soils Paddy Cotton + Pigeon pea Soybean+ Sorghum Sorghum+ Pigeonpea Sunflower **Medium deep to shallow black soils** Paddy	Intercropping of Cotton/Sorghum + Pigeon pea for moisture conservation or crop insurance. Keep seed bed saturated by applying light irrigation. Hoeing and Opening of furrow after every fourth row to conserve the moisture. If the cultivation and sowing is along the slope, open the intermittent furrow by lifting the hoe at 10-15 ft. distance instead of opening the continuous furrows.	Cultivation of Napier grass along the bunds to reduce erosion and augment fodder production to animals.	Afforestation of mining areas and community land with suitable local tree species like *Dendrocalamus strictus*, *Pongamia pinnata*, and *Azadirachta indica* etc. Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis*, *Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference.

10	**Osmanabad,TGA: 760.22:A(Er): 12.31 (2:8.80, 3:3.51) Er (%): 1.62, Sp.P: Gully erosion,**			
	Medium deep to deep black soils Pigeon pea Sorghum Black gram Soybean : Sunflower **Shallow soils** Pigeon pea Sorghum Black gram Soybean Pearl millet	Intercropping of Cotton/Sorghum + Pigeon pea for moisture conservation or crop insurance. Cover cropping with Black gram/ Green gram/Cowpea Adopt closer spacing of 60 × 30 cm for Pigeon pea. *In situ* moisture conservation through conservation furrows. Protective irrigation at critical stages. Mulching with crop residue @ 3-5 t/ha within the rows.	*Vetiver zizanioides* / *Leucaena leucocephala* / Dicanthium annulatum as vegetative barrier for moisture conservation and reduce runoff.	Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis*, *Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference. The growing of suitable perennial dry land horticultural to biotic interference. The growing of suitable perennial dry land horticultural crops such as Ber, Guava, Tamarind, Amla, Sapota Custard apple and Lime not only brings soil and water conservation in-situ, but also makes best use of available moisture.
11	**Suburban Mumbai, TGA: 44.05: A(Er): 13.64 (2:3.13, 3:10.51) Er (%): 30.62, Sp.P: Urbanization, flash floods**			
	Rice, Jowar, Mung, Wheat, Tur, Groundnut, Urad, Gram, and other pulses, Peanuts, Sunflowers, and Soybeans, Cotton, sugarcane, Turmeric, Vegetables Scrambling and trailing vine-like plant (Water melon, Musk melon), Coconut, Mango		Coconut, Mangroves	Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis, Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference.

12	**Latur, TGA:723.48: A(Er): 18.35 (2:17.66, 3:0.68):Er (%): 2.54, Sp.P: Gully erosion**			
	Medium deep to deep black soils Soybean Sorghum Pigeon pea Black gram Green gram **Shallow black soils** Soybean Sorghum Pigeon pea Black gram	Intercropping of Pigeon pea + Blackgram for moisture conservation or crop insurance. Making of conservation furrows for moisture conservation. Interculture for weeding and to create soil mulch. Sunhemp and Dhaincha are cultivated as green manuring crops. Cowpea and Blackgram as cover crop.	Drumstick and hedge lucerne as protective/ barrier crops.	Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis*, *Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference.
13	**Bhandara, TGA: 400.48: A(Er): 18.35 (2:17.66, 3:0.68):Er (%): 4.78, Sp. P: Gully erosion, Mining**			
	Deep to medium deep soils Paddy nursery Soybean Pigeon pea Linseed Gram **Shallow to medium deep soils** Paddy (Transplanted) Bandhi system Soybean Pigeon pea on paddy bunds	Intercropping of Pigeon pea + Blackgram for moisture conservation or crop insurance. Direct seeding of sprouted seed on puddled fields by using drum seeder. Sunhemp and Dhaincha are cultivated as green manuring crops. Cowpea and Blackgram as cover crop.	Drumstick and hedge Lucerne as protective/ barrier crops.	

14	**Jalgaon, TGA: 1174.69: A(Er): 22.00 (1:0.01, 2:17.03, 3:4.96):Er (%): 1.87, Sp.P: Gully erosion,**			
	Medium to deep black soils, Cotton Maize Groundnut Sesamum Sorghum Blackgram **Shallow to medium deep black soils** Desi Cotton Pearl millet Groundnut Green gram	Intercropping of maize + groundnut for moisture conservation or crop insurance. Opening of furrows for moisture conservation in between two rows. Sowing/planting on ridges & furrows for Sprinkler/Drip method of irrigation Cowpea and Blackgram as cover crop.	Drumstick and hedge Lucerne as protective/ barrier crops.	
15	**Wardha, TGA: 628.59: A(Er):23.64 (2:3.41, 3:20.23): Er (%): 3.76, Sp.P: Gully erosion,**			
	Deep & Medium deep black soils **Shallow black soils** Cotton Soybean Pigeon-pea Sorghum (Kh. Jowar) Wheat Gram	Intercropping of Cotton + Pigeon pea and Wheat + Gram for moisture conservation or crop insurance. Adopt closer spacing (60 × 30 cm) for Pigeonpea, Follow *in-situ* moisture conservation measures. Weeding inter-cultivation to create soil mulch to conserve moisture. Protective irrigation if possible. Follow alternate row irrigation/ irrigate at critical stages.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots.	

16	**Gondiya, TGA: 527.19: A(Er):25.47 (2:5.51, 3:19.96):Er (%): 4.83, Sp.P: Gully erosion, mining**			
	Deep to very deep soil Paddy Pigeonpea Wheat Gram Summer Paddy **Moderately deep soils on very gently sloping plains** Paddy-Paddy Paddy-Fallow Paddy-Gram Paddy-Wheat Pigeonpea-Fallow **Moderately deep soils on undulating topography** Paddy-Paddy Paddy-Fallow Paddy-Gram Paddy-Wheat Pigeon pea-Fallow	Intercropping of Cotton + Pigeon pea and Wheat + Gram for moisture conservation or crop insurance. Reduce plant spacing for both the crop (15 ×15 cm) and use higher seed rate. Frequent inter cultural operation to keep the weed under control and reduce evaporation losses. In-situ water harvesting or runoff recycling are the measures for crop life saving. May adopt relay cropping by sowing or broadcasting *Lathyrus* seed in standing paddy crop.	Drumstick and hedge Lucerne as protective/barrier crops.	
17	**Nagpur, TGA: 984.63: A(Er)33.47 (1:0.01, 2:11.92, 3:21.53) :Er (%): 3.40, Sp.P: Gully erosion, mining**			
	Deep & Medium deep black soils Cotton Cotton + Pigeon pea Intercropping Soy bean Paddy Pigeonpea (Kh. Sorghum) **Shallow black soils** Green gram Soybean + Pigeon pea intercropping	Follow *in-situ* moisture conservation measures. Adopt closer spacing (60 x 30 cm) for pigeonpea. Raising of nursery by Dapog method and transplanting in field Sowing of sprouted paddy seed by using drum seeder on puddled field. Rain water harvesting & recycling to be strengthened.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots.	

18	**Gadchiroli, TGA: 1449.06: A(Er):40.17 (2:6.42, 3: 33.74): Er (%): 2.77, Sp.P: Gully erosion**			
	Paddy Cotton Pigeon pea Soybean Sunflower	Sunhemp and Dhaincha are cultivated as green manuring crops. Cowpea, Green gram, and Black gram as cover crops.	Drumstick and hedge Lucerne as protective/ barrier crops.	
19	**Yavatmal, TGA: 1354.32:A(Er):41.05 (1:5.33, 2:25.87, 3:9.84): Er (%):3.03, Sp.P: Gully erosion, mining**			
	Cotton Soybean Pigeonpea Sorghum Greengram Black gram	Sunhemp and Dhaincha are cultivated as green manuring crops. Cowpea, Green gram, and Black gram as cover crops.	Drumstick and hedge Lucerne as protective/ barrier crops.	
	TGA (000 ha): 11698.73, Area under Severity of risk A: 262.92, % of TGA under risk: 2.25			
	Severity of risk- No risk			
20	**Aurangabad, TGA: 1014.86: A(Er):58.64 (1:4.37, 2:26.19, 3:28.08): Er (%): 5.78, Sp.P: Gully erosion and sodic soils**			
	Cotton Pearl millet Maize Pigeon pea Sorghum	Intercropping of Pigeon pea + Pearl millet for moisture conservation or crop insurance. Green manuring with Sunhemp or *Dhaincha* during summer. Planting *Leucaena leucocephala* on the field bund.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots.	Growing of Dhaincha for reducing soil pH. Growing of salt tolerant fruit crops like coconut.
21	**Thane, TGA: 426.29: A(Er):63.22 (1:16.86, 2:43.26, 3:3.10): Er (%):14.83, Sp.P:Water logging, Mining, saline and sodic soils**			
	Rice Finger millets Proso millet Groundnut Sesame	Intercropping of Groundnut + Sesame for moisture conservation or crop insurance. Green manuring with Sunnhemp or *Dhaincha* during summer. Planting *Leucaena leucocephala* on the field bund.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots.	Growing of Dhaincha for reducing soil pH. Growing of salt tolerant fruit crops like coconut.

22	**Amaravati, TGA: 1215.63: A(Er):63.31 (1:0.11, 2:50.64, 3:12.56): Er (%):5.21, Sp.P:Gully erosion, Saline and sodic soils, Mining**			
	Cotton Soybean Greengram Blackgram Pigeon pea *Kharif* Sorghum	Intercropping of Pigeon pea + Blackgram for moisture conservation or crop insurance. Green manuring with Sunnhemp or *Dhaincha* during summer. Greengram/Blackgram/Cowpea for cover cropping.	Planting of fodder grasses like Napier and Guinea for augmenting fodder yield as well as conserving soil and water.	Growing of Dhaincha for reducing soil pH. Growing of salt tolerant fruit crops like coconut.
23	**Bid, TGA: 1061.43: A(Er):95.37 (1:35.58, 2:52.38, 3:7.41): Er (%):8.98, Sp.P:Gully erosion,**			
	Cotton Bajra Sorghum Pigeon pea Soybean	Intercropping of Sorghum + Pigeon pea and for moisture conservation or crop insurance. Green manuring with Sunnhemp or *Dhaincha* during summer. Greengram/Blackgram/Cowpea for cover cropping.	Planting of fodder grasses like Napier and Guinea for augmenting fodder yield as well as conserving soil and water.	Growing of Dhaincha for reducing soil pH. Growing of salt tolerant fruit crops like coconut.
	TGA (000 ha): 3718.21, Area under Severity of risk B: 280.54, % of TGA under risk: 7.54			
	Severity of risk- No risk			
24	**Nandurbar, TGA: 586.64:A(Er):125.57 (1:45.76, 2:57.60, 3:22.22): Er (%):21.41, Sp.P:Gully erosion**			
	Cotton *Kharif* Sorghum Paddy Pearl millet Maize *Rabi* Sorghum Chick pea	Intercropping of Sorghum + Cotton for moisture conservation or crop insurance. Green manuring with *Dhaincha* during summer. Planting *Leucaena leucocephala* on the field bund.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots. Planting of fodder grasses like Napier and Guinea for augmenting fodder yield as well as conserving soil and water.	Bamboo + *Cenchrus ciliaris* planting or live check dam of bamboo for reducing the soil erosion

25	**Solapur, TGA: 1493.64: A(Er):208.75 (1:19.31, 2:145.17, 3:44.27) : Er (%):13.98, Sp.P:Gully erosion, sodic and eroded sodic soils**			
	Pigeonpea Sunflower Safflower Sorghum Chickpea Wheat	Intercropping of Sorghum + Pigeon pea and Wheat + Chickpea for moisture conservation or crop insurance. *Gliricidia* plants as green manuring to improve soil quality. Legume crops Green gram and Cowpea cultivated as cover crop for improving soil fertility.	*Vetiver zizanioides* / *Leucaena leucocephala* / *Dicanthium annulatum* as vegetative barrier for moisture conservation and reduce runoff.	Block plantation & community land afforestation - Raising of forest tree and plantations (*Tectona grandis*, *Azadirachta indica*, *Glyricidia sepium*) on lands which were not covered with forest and were reduced to scrub due to biotic interference. The growing of suitable perennial dry land horticultural crops such as Ber, Guava, Tamarind, Amla, Sapota, Custard apple and Lime not only brings soil and water conservation in-situ, but also makes best use of available moisture.
26	**Sangli, TGA: 869.51: A(Er):214.19 (1:63.95, 2:105.47, 3:44.76): Er (%):24.63, Sp.P:Gully erosion, Eroded sodic soils, Mining**			
	Sorghum Soybean Sugarcane Pearl millet Groundnut	Intercropping of Sugarcane + pulse crop for moisture conservation or crop insurance. Sunhemp or Dhaincha for green manure. Greengram/Blackgram/Cowpea for cover cropping.	*Saccharum spontaneum* (Kanna), *Eulaliopsis binata* (Bhabar grass), *Pennisetum purpureum*, *Vetiver zizanioides* for moisture conservation and reducing soil erosion by binding the soil by fine roots.	Prevention of forest fires and illegal wood cutting, Prevention of grass fires, Control of grazing, and re-vegetation of open and grass lands.
27	**Dhule, TGA: 715.12: A(Er):292.46 (1:97.70, 2:144.48, 3:50.27): Er (%):40.90, Sp.P:Gully erosion**			
	Shallow black soils **Medium deep black soils** **Deep black soils** Cotton *Kharif* Sorghum Maize Pearl millet Paddy *Rabi* Sorghum Chick pea	Intercropping of Cotton + Sorghum for moisture conservation or crop insurance. Sunnhemp or Dhaincha for green manure. Greengram/blackgram/cowpea for cover cropping.	*Saccharum spontaneum* (Kanna), *Eulaliopsis binata* (Bhabar grass), *Pennisetum purpureum*, *Vetiver zizanioides* for moisture conservation and reducing soil erosion by binding the soil by fine roots.	

28	**Kolhapur, TGA: 777.27: A(Er):295.94 (1:86.60, 2:167.48, 3:41.86): Er (%):38.08, Sp.P: Gully erosion, Sodic soils, Mining**			
	Shallow lateritic soils **Medium deep black soils** **Deep brownish soils** Sugarcane Paddy Finger millet Soybean *Kharif* Sorghum Groundnut	Intercropping of Sugarcane + pulses for moisture conservation or crop insurance. Sunhemp as green manure, Greengram and Blackgram as mulch.	*Saccharum spontaneum* (Kanna), *Eulaliopsis binata* (Bhabar grass), *Pennisetum purpureum*, *Vetiver zizanioides* for moisture conservation and reducing soil erosion by binding the soil by fine roots.	Prevention of forest fires and illegal wood cutting, Prevention of grass fires, Control of grazing, and re-vegetation of open and grasslands,
29	**Sindhudurg, TGA: 512.59: A(Er): 307.46 (1:106.80, 2:156.55, 3:44.11): Er (%): 59.98, Sp.P: Gully erosion, Acid soils, Mining**			
	Upland medium deep to shallow soils Rice Finger millet Groundnut Niger (Karla) Sugarcane **Mid-land medium deep soils** Low land deep soils Hill slope shallow soils	Intercropping of Wheat + Chickpea for moisture conservation or crop insurance. Dapog nursery raising /sowing of sprouted seed. Sunnhemp as green manure, Greengram/Black gram/Cowpea as cover crop. Mulching with *Glyricidia* leaves.	*Saccharum spontaneum* (Kanna), *Eulaliopsis binata* (Bhabar grass), *Pennisetum purpureum*, *Vetiver zizanioides* for moisture conservation and reducing soil erosion by binding the soil by fine roots.	For flood: provide drainage by constructing drainage channel of 25-30 cm deep. For deforestation and mine rehabilitation: *Cassia mimosoides*, *Bothriochola pertusa*, *Cymbopogon spp*, *Cassia auriculata*, *Tephrosia purpurea*, *Indigofera cassioides*, *Accacia catechu*, and *Albizia lebbeck*,
30	**Palghar, TGA: 526.70: A(Er):344.35 (1:141.52, 2:187.43, 3:15.41): Er (%):65.38, Sp.P: Gully erosion**			
	Upland medium deep to shallow soils Rice Finger millets Proso millet Groundnut Sesame	Intercropping of Finger millet + groundnut for moisture conservation or crop insurance. Protective irrigation during critical stages.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots.	

	Mid-land medium deep soils Low land deep soils Hill slope shallow soils	Mulching with *Glyricidia* green leaves or Live weed mulching. Green manuring with *Dhaincha* during summer. Planting *Leucaena leucocephala* on the field bund.	Planting of fodder grasses like Napier and Guinea for augmenting fodder yield as well as conserving soil and water.	
31	**Rantagiri, TGA: 829.65: A(Er):417.86 (1:141.69, 2:200.91, 3:75.27): Er (%):50.37, Sp.P: Gully erosion, Acid soils, Mining**			
	Upland medium deep to shallow soils Rice Finger millet Groundnut Black gram Niger	Intercropping of Wheat + Chickpea for moisture conservation or crop insurance. Mulching with tree lopping or *Glyricidia* leaves. Sunhemp and Dhaincha are cultivated as green manuring crops. Dapog or mat technique of nursery raising for young seedling transplanting through SRI Technique	Horticulture/ Plantation crops like Cashew, Arecanut, Coconut, Mango and Banana	Cultivation of flood resistant red rice variety: Sahyadri Panchamukhi
32	**Ahmadnagar, TGA: 1710.50: A(Er):492.85 (1:141.25, 2:242.04, 3:109.56): Er (%):28.81, Sp.P: Gully erosion, Sodic & Eroded sodic soil**			
	Shallow Grey soils **Medium Deep black soils** **Deep black soils** Soybean Pearl millet Sugarcane Wheat *Rabi* Sorghum Chickpea	Intercropping of Wheat + Chickpea for moisture conservation or crop insurance. One hoeing and weeding before 30 DAS. Alternate furrow irrigation/ Trash mulching. Drip irrigation, Paired row planting, alternate furrow irrigation & trash mulching	*Leucaena leucocephala*, *Gliricidia sepium* & *Cymbopogon flexuosus* as vegetative barrier for moisture conservation and reduce runoff	Growing of Dhaincha for reducing soil pH.

33	**Satara, TGA: 1053.30: A(Er):506.48 (1:176.29, 2:211.61, 3:118.58): Er (%):48.09, Sp.P: Gully erosion, mining**			
	Shallow Grey/black soils **Medium black soils** **Deep black soils** Pearl millet Ground nut Kharif Sorghum Paddy Soybean *Rabi* Sorghum Wheat Chickpea Sugarcane	Intercropping of Pearl millet + Groundnut for moisture conservation or crop insurance. Sunnhemp or Dhaincha for green manure. Greengram and Black gram for cover crop.	*Leucaena leucocephala*, *Gliricidia sepium* & *Cymbopogon flexuosus* as vegetative barrier for moisture conservation and reduce runoff.	Growing of Vetiver, Lemon grass, *Glyricidia* and Cenchrus as vegetative barrier to control runoff and soil loss in mine spoil area and block plantation & community land afforestation - Raising of forest tree and plantations (Teak, Neem and *Glyricidia*) on lands which were not covered with forest and were reduced to scrub due to biotic interference.
34	**Raigarh, TGA: 723.59:A(Er):518.01 (3:338.18, 2:159.24, 3:20.59): Er (%):71.59, Sp.P: Gully erosion, mining**			
	Upland medium deep to shallow soils **Mid-land medium deep soils** **Low land deep soils** **Hill slope shallow soils** **Khar land** Rice Finger millets Groundnut Wal (Lablab bean) Blackgram	Sunhemp and Dhaincha for green manuring Blackgram/Greengram/Cowpea as cover crops Intercropping of Finger millet + Black gram for moisture conservation or crop insurance.	Horticulture/ Plantation crops like Cashew, Arecanut, Coconut, Mango and Banana Bio-shielding of the Coast: Coastal bio-shields include Mangroves; Casuarina plantations protect from wave and tide action, especially during storms.	Sea water intrusion to agriculture lands: Leaching, Selection of salt tolerant varieties, Sowing and in-situ ploughing of green manure species (*Sesbania aculeate*). Use of Vetiver (*Vetiveria zizanioides*) for dune stabilization. Bio-shielding of the coast through planting of following species of grass and trees: *Spinifex littoreus, Ipomoea pescaprae, Canavalia spp, Pandanus spp, Borassus flabellifer* and *Morinda citrifolia.*
35	**Pune, TGA: 1568.61: A(Er):533.91 (2:272.69, 2:203.35, 3:57.87): Er (%):34.04, Sp.P: Gully erosion, sodic and eroded sodic soils**			
	Shallow red /grey soils Lowland Paddy Pearl millet Groundnut	Opening of conservation furrows after every two rows. Inter cropping of Wheat + Chick pea for moisture conservation and crop insurance.	Rainwater harvesting through farm ponds	Prevention of forest fires and illegal wood cutting, prevention of grass fires, control of grazing, and re-vegetation of open and grass lands,

	Sorghum Chick pea Wheat **Medium deep black Soils** **Deep black soils** Sorghum Groundnut Pigeon pea	Cover cropping and green manuring with Cowpea and Sunhemp, respectively.		
36	**Nasik , TGA: 1546.49: A(Er):576.36 (2:242.56, 2:248.39, 3:85.41): Er (%):37.27, Sp.P: Gully erosion, sodic and eroded sodic soils**			
	Shallow red soils Pearl millet Maize/Groundnut Low land Paddy (Rainfed) Finger millet Onion Wheat **Medium red / black soils** Low land Paddy (Rainfed) Maize Niger Sugarcane **Deep black soils** Maize Onion	Opening of furrows for moisture conservation Green manuring with *Dhaincha* during summer. Planting *Leucaena leucocephala* on the field bund. Intercropping of Maize + Groundnut for moisture conservation and crop insurance.	Planting of aromatic plants (Lemon grass) for moisture conservation and reducing soil erosion by binding the soil by fine roots. Planting of fodder grasses like Napier and Guinea for augmenting fodder yield as well as conserving soil and water.	Bamboo + *Cenchrus ciliaris* planting or live check dam of bamboo for reducing the soil erosion.
	TGA (000 ha): 12913.62, Area under Severity of risk C: 4834.21, % of TGA under risk: 37.43			

Note : Severity risk - No risk: Area under (Er-T) > 15 t ha^{-1} yr^{-1} is nil however some area having more than 10 t ha^{-1} yr^{-1} need to be treated. 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, 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. (Er – TL); 1: (Er –TL) >35 t ha^{-1} yr^{-1}, 2: (Er – TL) in the range of 25-35 t ha^{-1} yr^{-1}, 3: (Er – TL) in the range of 15-25 t ha^{-1} yr^{-1}. (Table 4.2) represents different soil and water conservation engineering measures for different land situations, (Table 4.3) presents agronomic and vegetative measures and (Table 4.4) represents district wise potential agro-forestry system (AFS).

Table 4.4 Agroforestry solution for soil and water conservation in Maharashtra

S. No.	Agro climatic zones	Districts	Agroforestry System
1	North Konkan Coastal Zone	Palghar, Thane, Raigad, Mumbai city, Mumbai suburban	**a) Block plantation** *Acacia mangium/ Casuarina equisetifolia/Khaya senegelensis* **b) Agri-silviculture** *Acacia mangium* + Turmeric **c) Agri-horticulture** *Mangifera indica/Anacardium occidentale/Cocus nucifera/Emblica officinalis/Garcinia indica* + Paddy/Groundnut/Niger/Finger millet/Proso millet
2	South Konkan Coastal Zone	Ratnagiri, Sindhudurg	**a) Agri-horticulture** *Mangifera indica/Anacardium occidentale/Cocus nucifera/Emblica officinalis/Garcinia indica* + Paddy/Finger millet/Proso millet **b) Paddy based agri-silviculture system** **Suitable tree species:** Butea monosperma/ *Tectona grandis/ Eucalyptus tereticornis/Dalbergia sissoo/ Santalum album/Gmelina arborea* **Suitable fruit trees:** *Mangifera indica, Zizyphus rotundifolia, Annona reticulate/ Psidium guajava*
3	Western Ghat Zone	Nandurbar, Kolhapur, Satara, Pune, Ahmednagar, Nasik, Sindhudurg	**a) Agri-horticulture system** *Mangifera indica/ Phyllanthus emblica + Cicer arietinum/Glycine max* **b)Agri-silviculture** *Tectona grandis* + *Vigna unguiculata* / *Vigna mungo* **c) Silviculture** *Azadirachta indica/Eucalyptus camaldulensis/ Melia azadirachta/Tectona grandis/Hardwickia binata/Acacia nilotica/Zizyphus mauritina*
4	Sub Mountain Zone	Nandurbar, Nasik, Pune, Satara, Sangli, Kolhapur	**a) Three tier fruit based agroforestry model** **Suitable fruit trees:** *Citrus sinesis*, *Citrus limetta*, *Citrus limon* **Suitable trees:** *Eucalyptus tereticornis/Melia dubia/ Ailanthus excelsa* **Inter crops:** Kharif - *Glycine max /Sorghum bicolor/Vigna mungo/Vigna radiata*; Rabi: *Triticum aestivum*, *Macrotyloma uniflorum*, *Brassica nigra*, *Linum usitatissimum*, *Lathyrus sativus*, vegetables, fodder crops.

5	Western Maharashtra Plane Zone	Dhule, Ahmednagar, Nasik, Pune, Satara, Sangli, Kolhapur	**a) Ailanthus Based Agri-silviculture Model** **Tree species:** *Ailanthus excelsa* **Inter crops:** Kharif -*Glycine max*/*Sorghum bicolor*/ *Gossypium* / *Vigna mungo* /*Vigna radiata*; Rabi: *Macrotyloma uniflorum*, *Brassica nigra*, *Linum usitatissimum*, *Lathyrus sativus* fodder crops, vegetables. Shade loving crops after 10 yrs.
6	Western Maharashtra Scarcity Zone	Jalgaon, Dhule, Nasik, Aurangabad, Ahmednagar, Pune, Satara, Solapur, Sangli	**a) Bamboo Based Agroforestry Model** **Bamboo species:** *Bamboosa balcooa , D. stocksii, D. asper , B. tulda* **Intercrops:** Kharif - *Glycine max* /*Sorghum bicolor*/*Vigna mungo*/*Vigna radiata*; Rabi: *Triticum aestivum*, *Macrotyloma uniflorum*, *Brassica nigra*, *Linum usitatissimum*, *Lathyrus sativus*, vegetables, fodder crops.
7	Central Maharashtra Plane Zone	Aurangabad, Jalna, Beed, Osmanabad, Parbhani, Nanded, Hingoli, Latur	**a) Boundary plantation** *Tectona grandis/Terminalia bellirica/Butea monosperma/ Diospyros melanoxylon/Ailanthus excels/Wrightia tinctoria* ***b)* Agri-horticulture system** *Citrus sp./Mangifera indica/ Psidium guajava + Glycine max/Arachis hypogaea /Oryzia sativa/ Sesamum indicum + Sorghum bicolor/Cajanus cajan/ Helianthus annus / Capsicum annuum* **c) Agri-silviculture** *Madhuka latifolia/Ficus racemosa/Ficus benghalensis/Tectona grandis/Azadirachta indica/ Butea monosperma/Ailanthus excelsa + Glycine max/Arachis hypogaea / Sorghum bicolor/Cajanus cajan/ Gossypium, Vigna radiata/Vigna mungo/ Helianthus annus* **d) Homestead garden** *Pongamia pinnata/Butea monosperma/ Bauhinia purpurea/Ficus benghalensis/Ficus religiosa/ Albizia saman + Annona squamosa / Punica granatum / Psidium guajava / Carica papaya / Musa sp. / Citrus limon / Syzygium cumini / Moringa oleifera*

8	Central Vidarbha Zone	Wardha, Nagpur, Yavatmal, Chandrapur, Amravati, Washim, Akola, Buldhana	**a) Agri-horti-silviculture system** *Tectona grandis/ Eucalyptus tereticornis/ Ailanthus excelsa* + *Citrus reticulata* + *Vigna unguiculata / Vigna mungo / Brassica nigra* **b) Silvipasture** *Acacia nilotica* + *Cenchrus ciliaris* + *Stylosanthes hamata* for light soils and *Annona squamosa* + *Cenchrus ciliaris* + *Stylosanthes hamata* for medium soil.
9	Eastern Vidarbha Zone	Bhandara, Gadchiroli, Chandrapur, Nagpur, Gondia	**a) Paired row Boundary plantation** **Major crops:** Kharif - *Oryza sativa; Macrotyloma uniflorum, Brassica nigra , Linum usitatissimum, Lathyrus sativus, Summer Glycine max, Triticum aestivum*, fodder crops. **Suitable trees:** *Tectona grandis/ Eucalyptus tereticornis/ Azadirachta indica/Dalbergia sissoo/ Santalum album/Gmelina arborea* **Suitable fruit trees:** *Mangifera indica, Zizyphus rotundifolia, Annona reticulate/ Psidium guajava* b) Teak Based Agri-silviculture Model Tree species: *Tectona grandis* **Inter crops:** Kharif -*Glycine max/Sorghum bicolor/ Gosypium sp./Vigna mungo/Vigna radiata; Rabi: Macrotyloma uniflorum, Brassica nigra, Linum usitatissimum, Lathyrus sativus*, and fodder crops; Shade loving crops after 10 yrs.

5.0. CONCLUSION

The Maharashtra state can be divided into four meteorological regions, namely coastal Konkan, Western Maharashtra, Marathwada, and Vidarbha has about 17.48% area in the need of soil and water conservation indicating water erosion as a major problem of the state. With the climate varies from arid and semi-arid in the plateau region to humid tropical monsoonic type in the west coast plains the state is facing both water shortage and excess soil eorison. The rate of soil erosion in Maharashtra is the highest in the country. In fact, according to a recent estimate by the National Bureau of Soil Survey and Land Use Planning, 96.4% of the land area is degraded to various degrees, and 40.6% is degraded severely. The quantity of soil erosion per year in Maharashtra is 773.5 million tonnes, and 94% of that erosion is water induced. The detrimental effects of soil erosion are reflected in the land's declining productivity.

In the Maharashtra state the area of 1938.06 thousand hectares, 2512.42 thousand hectares and 927.17 thousand hectares are under severity risk category 1 (Very high risk), 2 (high risk) and 3 (medium risk) respectively. Raigadh, Palghar, Sindhudurg, Ratnagiri, Satara, Dhule, Kolhapur, Nasik, Pune, Ahmadnagar, Snagli, Solapur, Nandurbar are the dominant districts in terms of area under erosion risk. The high erosion from high slope hilly region, deforestation, open scrub, mining, coastal erosion, floods, salinity and sodicity due to negative effects of large dams, siltation of reservoirs and water scarcity are the special problem of Maharastra. Almost all the possible bioengineering measures needs to be applied in different part of Maharastra and has been suggested in the document. The proposed approach considered the soil erosion risk areas with production losses of major crops integrating. The wide range of agronomic and vegetative measures, engineering measures and agroforestry measures have been suggested with aim to bring down the erosion rate below the soil loss tolerance limit. The document will help prioritizing the area to be treated and the selection of specific soil and water conservation measures for execution of site-specific best management practices.

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