



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



**ICAR- Indian Institute of Soil and Water Conservation
Research Centre, Udhagamandalam -643 004**



ISBN: 978-93-94687-29-5

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



ICAR-Indian Institute of Soil & Water Conservation,
Research Centre, Udhamandalam-643004, The Nilgiris, Tamil Nadu





Citation

Vanitha, S. M., Hombegowda H.C., Kannan, K., Mandal, D., Dogra, P., Kumar, G., Kaushal, R., Roy, T., Islam, S., Madhu, M. and Mandal, U. 2023. Soil erosion status, priority treatment areas and conservation measures for different districts of Chhattisgarh. ISBN: 978-93-94687-29-5, 42p.

Compiled and edited by

S. M. Vanitha, H.C. Hombegowda, K. Kannan, D. Mandal, P. Dogra, G. Kumar, R. Kaushal, T. Roy, S. Islam, M. Madhu and U. Mandal

Published by

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

All Rights Reserved
2023, ICAR-IISWC, Dehradun



भारतीय कृषि अनुसंधान परिषद

कक्ष क्र. 101, कृषि अनुसंधान भवन-II, नई दिल्ली-110 012, भारत

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Room No. 101, Krishi Anusandhan Bhavan-II, Pusa, New Delhi-110012, India

डॉ. सुरेश कुमार चौधरी

उप महानिदेशक (प्राकृतिक संसाधन प्रबंधन)

Dr. Suresh Kumar Chaudhari

Deputy Director General (Natural Resources Management)

19.06.2023




Foreword

Land resources have enormous economic, ecological and social relevance. Land degradation due to soil erosion is the major cause of decreasing interest in agriculture among the farmers in Chhattisgarh. The risk of soil erosion in Chhattisgarh is mainly due to high intensity rainfall, deforestation, overgrazing and faulty land use practices thus leading to their abandonment. The state has 65% of the area prone to erosion problem which needs to be addressed on priority. 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. The restored degraded land will ensure food and livelihood security besides providing ecosystem services.

I am happy to know that ICAR-Indian Institute of Soil & Water Conservation, Dehradun along with its Research Centre-Udhagamandalam is bringing out this valuable document of soil erosion status and erosion induced losses, conservation priority map and district specific soil and water conservation measures. I am sure, the document would be immensely useful to the executives, field functionaries and other stakeholders engaged in the dissemination of soil and water conservation technologies in the watersheds.

I appreciate the efforts made by the authors for bringing out this document in the field of vital importance which is very timely and pertinent.



(S.K. Chaudhari)

PREFACE

The ICAR- Indian Institute of Soil and Water Conservation (ICAR-IISWC), Dehradun is one of the national institutes of Natural Resource Management Division (NRM) of the Indian Council of Agricultural Research, Ministry of Agriculture and Farmer's Welfare, Govt. of India. The Institute along with its eight Research Centres in different agro-ecological region is specifically working in collaboration with other stakeholders for scientific planning, conservation and management of the natural resources particularly soil and water. The background of development of this document on "Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of Chhattisgarh" lies in the deliberations and subsequent recommendation of the Regional committee-VIII. The committee felt the need of developing strategy for arresting soil erosion on priority for sustainable development of all the states across the country.

The present document aimed at identification of critical areas based on the permissible soil erosion rate and existing erosion rate at a given location in each district of Chhattisgarh. The document contains soil erosion status and erosion induced losses including production and monetary losses at national level as well as for Chhattisgarh. Conservation priority map and district specific agronomic, vegetative and engineering measures have also been included in order to accelerate the adoption and implementation of soil and water conservation (SWC) measures and facilitate the need of various stake holders. The list of location specific SWC measures for each district have been compiled as ready reckoner for policy makers, researchers, planners, NGOs and extension functionaries to address the various issues of land degradation. The authors duly acknowledge the help rendered by the agricultural department of Chhattisgarh.

(Authors)

CONTENTS

Chapter. No	Chapter	Page No.
1.0	Introduction	
2.0	Land Degradation through Soil Erosion and its Impacts	2-3
2.1	Land Degradation	2
2.2	Gross Erosion Rate	2
2.3	Production & Monetary Loss	2
2.4	Nutrients Loss	2
2.5	Carbon Loss	2
2.6	Loss in Reservoir Capacity	3
3.0	The Approach	4
4.0	Erosion Status, Production and Monetary Loss and Conservation Planning for the State of Chhattisgarh	5-33
4.1	About the State	5
4.2	Soil Erosion Rate	5-6
4.3	Soil Loss Tolerance Limit (SLTL)	6-7
4.4	Production and Monetary Loss from Rainfed Crops due to Soil Erosion	7-9
4.5	Area under Risk and Treatment Measures	9-33
5.0	Conclusion	34
6.0	References	35-36
	Photographs	37-42

LIST OF TABLES

Table No.	Title	Page No.
4.1	District wise severity of erosion areas and critical problem with their possible solutions in Chhattisgarh	10-14
4.2	Proposed soil and water conservation measures for different soil erosion priority classes	15-18
4.3	District wise agronomic and vegetative soil and water conservation (SWC) measures proposed for the state of Chhattisgarh	19-30
4.4	Agroforestry solutions for soil and water conservation in Chhattisgarh	31-33

LIST OF FIGURES

Fig No.	Title	Page No.
2.1	Soil erosion and associated losses in India (GER-Gross erosion rate)	3
4.1	Priority classes for erosion control in Chhattisgarh state	6
4.2	Soil loss tolerance limit (SLTL) map of Chhattisgarh state	7
4.3	Estimated total production loss of rainfed crops due to soil erosion in Chhattisgarh State	8
4.4	Estimated total monetary loss of rainfed crops due to soil erosion in Chhattisgarh State	8
4.5	Estimated productivity (kg ha^{-1}) and monetary loss (Rs ha^{-1}) of rainfed crops due to soil erosion in Chhattisgarh State	9

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 pressure, developmental activities, un-scientific land use and land management practices. The risk of soil erosion in Central Indian states 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. About 65% and 59% of total geographical area (TGA) of Chhattisgarh and Madhya Pradesh respectively, experiences water erosion. Out of this 51% and 37% of area experiences severe to extreme erosion problem in Chhattisgarh and Madhya Pradesh, respectively.

Further, these states suffer an annual production loss of 24.6%, 20% and 23.5%, respectively due to water erosion in rainfed cereal, oilseed and pulse crops (Sharda and Dogra, 2013). 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, 2013). Hence, it is imperative to quantify the risks associated with overuse of soil functions, which leads to land degradation and consequently impacting on the eco-system services.

2.0**LAND DEGRADATION THROUGH SOIL EROSION AND ITS IMPACTS**

2.1 Land Degradation: In India, about 121.7 Mha area, which includes arable and non-arable lands, is subjected to various forms of land degradation (ICAR 2010), with maximum (82.6 Mha, 68.4%) contribution by water erosion (49% area accounts for soil loss $>10.0 \text{ t ha}^{-1}\text{yr}^{-1}$). 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% from 4937 big dams and average life span reduction of dams by 25 yrs (Range 8-53 yrs).

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 Mt (Sharda et al., 2010) valued at Rs 29,200 crore during 2015-16 (Sharda and Dogra, 2013).

2.4 Nutrients Loss: A significant amount (8 to 11 M t of NPK) of nutrients gets transported with runoff and eroded soil leading to net loss of ecosystem services. Soil loss resulting in loss of 5.37 to 8.40 M t of nutrients in India (Sharda and Ojasvi, 2016) estimated total monetary loss of Rs.38,540 to 45,410 crores annually (2020 price). 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 million tonnes amounting to the corresponding monetary loss of 13,500-29,300, 1,850-8,320, 17,300 and 5,890-7,790 crore rupees (2020 price), 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 1100 Mt C into the atmosphere as a result of soil erosion and another, 300-800 Mt C annually to the ocean (Lal, 2011). Quantity of organic C displaced 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 Loss in Reservoir Capacity: The total sediment trapped in the reservoirs with a total gross capacity of 299.5 Gm³ was estimated at 1679 M m³ 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 m³. Smaller dams of 1 to 50 M m³ 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).

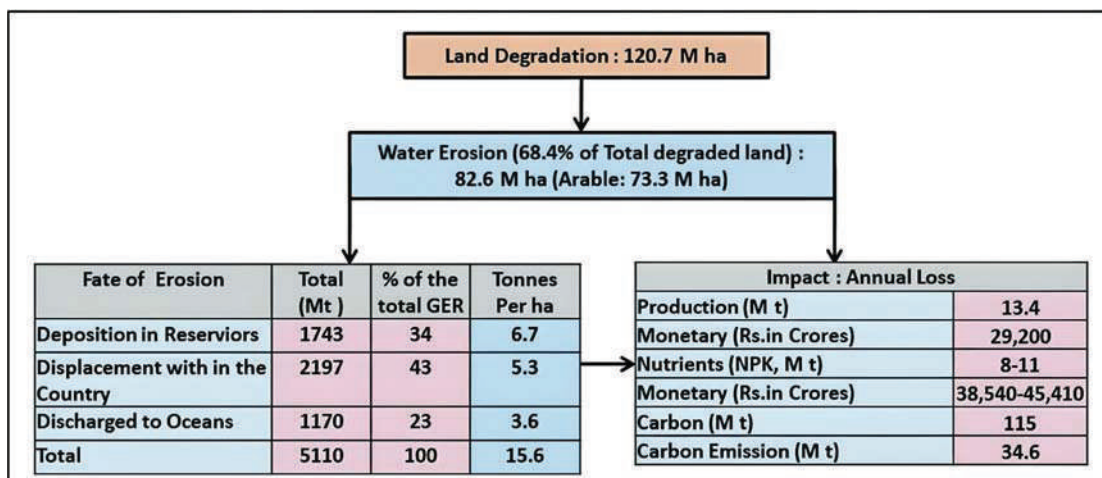


Fig. 2.1. Soil erosion and associated losses in India (GER- Gross erosion rate)

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. 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 prioritisation/risk area was assessed from the data base on potential soil erosion rates and soil loss tolerance limits for the state of Chhattisgarh. 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 – 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 peninsular India 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 (Kannan et al., 2021; Hombegowda 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 Chhattisgarh 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 CHHATISGARH

4.1 About the State

Chhattisgarh is a state of India. It was formed on 1st November 2000. The geographical location of Chhattisgarh is 17°46' to 24°5' North Latitude and from 80°15' to 84°20' East Longitude. The total geographical area (TGA) of the state is around 138 Lakh ha with net sown area of 46.51 Lakh ha, which is 34% of its TGA. This state is surrounded by high and low mountain ranges with dense forests. Chhattisgarh is one of the richest bio-diverse area in the country with around 63.4 Lakh ha area under forest cover, which is 46% of its TGA. The major rivers of the state are Mahanadi, Shivnath, Kharun, Sondhur, Arpa, Pari and Indravati. The annual average rainfall of the state is 1190 mm and about 88% of the total rainfall is received in the monsoon season (15th June to September). Its climate is mainly of dry sub-humid type. The state has three agro-climatic zones viz., Chhattisgarh plains, Bastar plateau and Northern hills region. About 57% area has medium to light soil. Central plain of Chhattisgarh is known as Rice Bowl of Central India. Paddy, soybean, black gram and red gram are the major *Kharif* crops while in *Rabi* season mainly chickpea and lathyrus are grown. The other crops grown are sugarcane, maize, millets, green gram, wheat, groundnut, niger and sunflower. Mango, guava, lime, litchi and sapota are the major fruit crops grown in the state over 2.5 lakh ha. Agro climatically mango can be grown in the whole part of the state successfully while the northern hilly area of Sarguja and Jashpur district is suitable for production of litchi. Cashew nut can be grown well in the plateau region of the Bastar and Raigarh district. Vegetables such as tomato, brinjal, cucurbits, beans, cabbage, cauliflower etc., are grown in an area of 4.9 lakh ha. Spices like chilli, ginger, garlic, turmeric and coriander are also cultivated in 0.67 lakh ha.

4.2 Soil Erosion Rate

Data pertaining to potential soil erosion rates, soil loss tolerance limits and priority classes in the state revealed that an area covering 3.86 M ha (25.9% of TGA) has severe (25-35 t ha⁻¹ yr⁻¹) and very severe (>35 t ha⁻¹ yr⁻¹) soil erosion rates whereas the low (<15 t ha⁻¹ yr⁻¹) and moderate (15-25 t ha⁻¹ yr⁻¹) erosion classes cover 18.8% and 7.9% area, respectively (Fig.4.1).

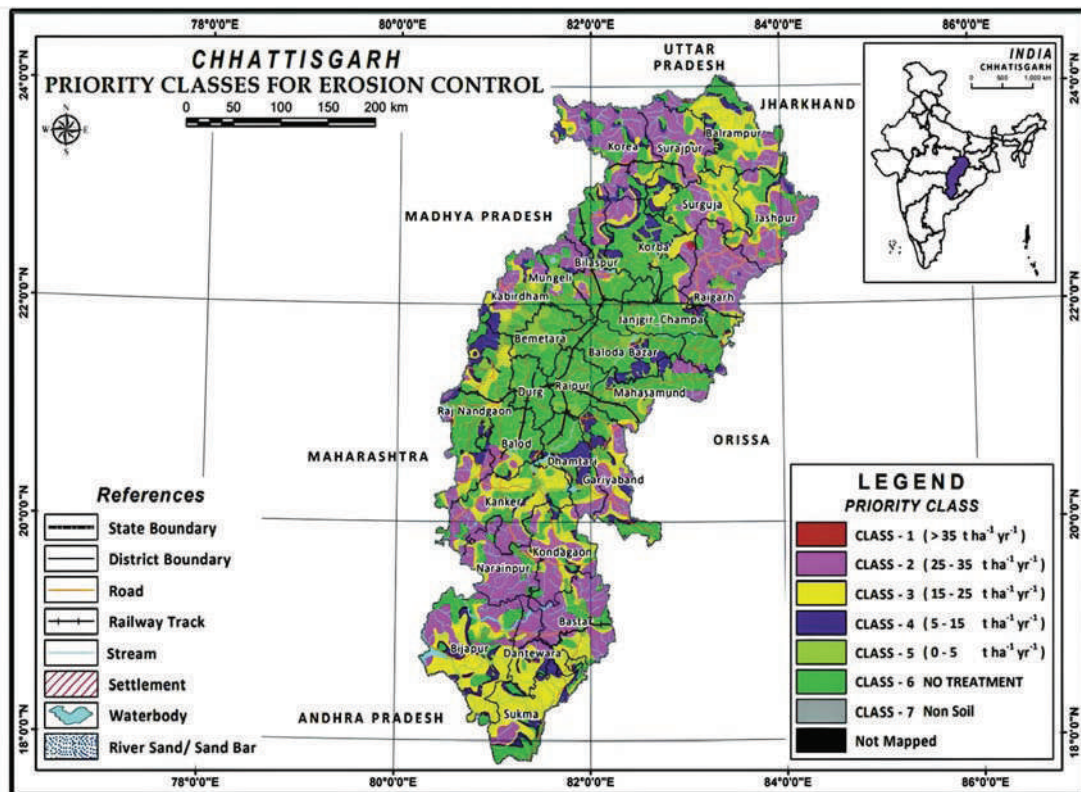


Fig. 4.1. Priority classes for soil erosion control in Chhattisgarh state

4.3 Soil Loss Tolerance Limit (SLTL)

The soil loss tolerance limit values for Chhattisgarh varied between 5.0 and 12.5 Mg ha⁻¹ yr⁻¹, indicating a high degree of soil heterogeneity with respect to soil depth, infiltration, bulk density, organic matter content, erodibility and pH within the same physiographic region. The areas of major concern are the eastern Baghelkhand plateau and Eastern plateau Mahanadi basin, where a considerable area is able to tolerate only low soil loss up to 5.0 Mg ha⁻¹ yr⁻¹. Therefore, these areas are most sensitive and need due attention during cultivation. Eastern Chhotanagpur plateau ranked first with respect to overall mean soil condition. In Eastern part of the region, soils can afford a higher soil loss (above 5.0 Mg ha⁻¹ yr⁻¹) as compared to the other regions. Soil loss tolerance values were highest in the Eastern Dandakarnya and Chhotanagpur plateaus. The spatial distribution of tolerance limits in the state is presented in Fig. 4.2

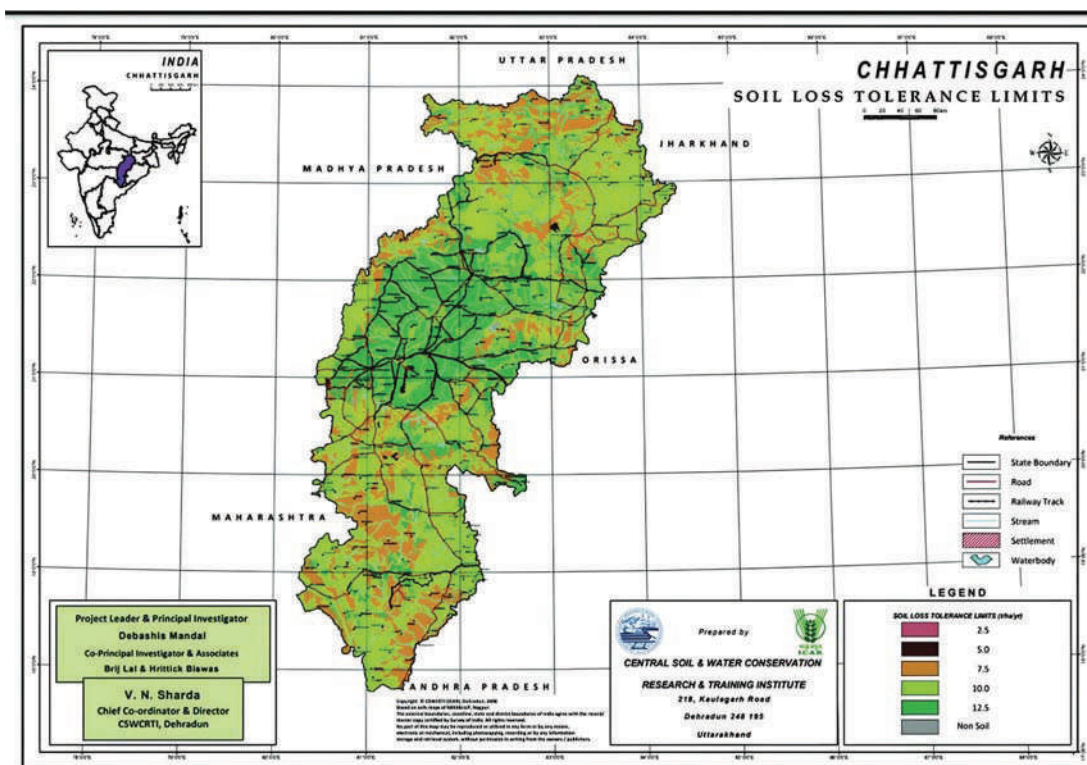


Fig. 4.2. Soil loss tolerance map of Chhattisgarh

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 27%, 33% and 23%, respectively, and consequently, average loss considering cereals, oil seeds and pulses together is about 27%. Out of 1.01-million-ton total production losses, 89.0% is due to losses in cereals and millets, 3.5% in oilseeds and 7.5% in pulses (Fig. 4.3). In terms of monetary losses, 74.2% of the total loss of Rs 21,395 million occurs in Chhattisgarh due to production losses in cereals and millets, followed by 18.3% in pulses, and 7.5% in oilseeds (Fig. 4.4). The largest contribution is from paddy (67%) followed by gram (6%), and blackgram (6%).

The productivity losses of cereal and millets, oilseed and pulse crops were estimated to be 287 kg ha⁻¹, 125 kg ha⁻¹ and 85 kg ha⁻¹, respectively. The average productivity loss of all these crops together is 235 kg ha⁻¹ (Sharda and Dogra, 2013), which in monetary terms was Rs 4994 ha⁻¹ during 2018-19 (Fig 4.5). The Gross State Domestic Product (GSDP) of Chhattisgarh for 2018-19 at current prices was estimated to be Rs 3,25,644

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 0.66% of its GSDP during 2018-19.

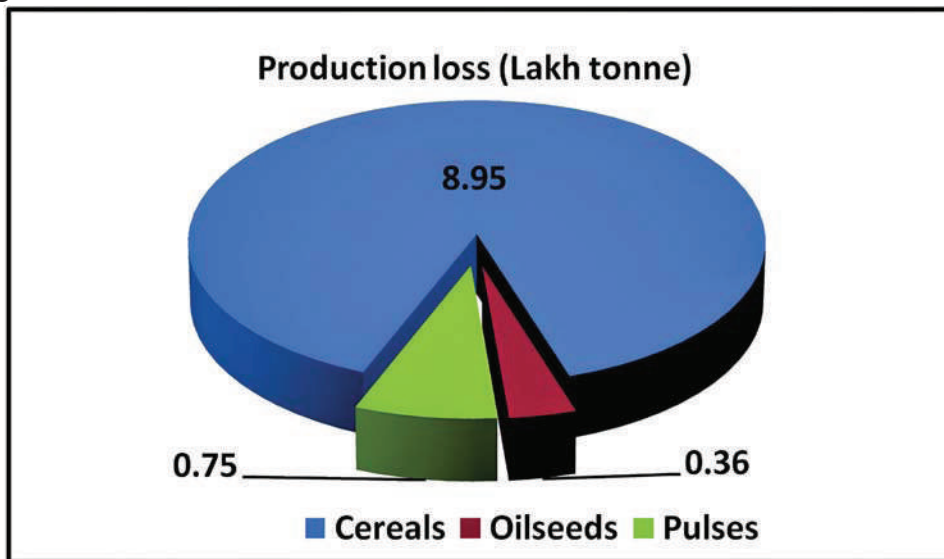


Fig. 4.3. Estimated total production loss of rainfed crops due to soil erosion in Chhattisgarh State

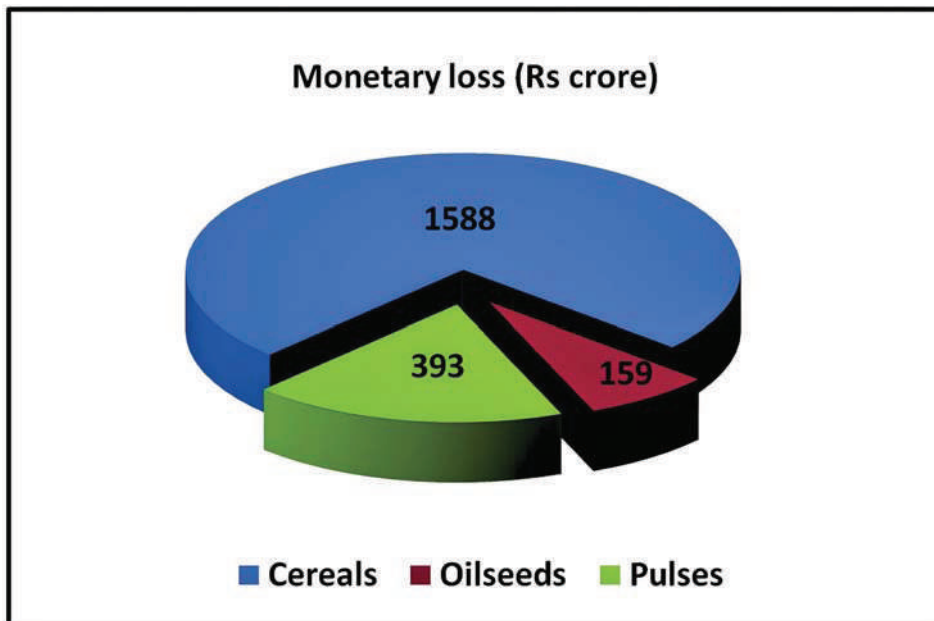


Fig. 4.4. Estimated total monetary loss of rainfed crops due to soil erosion in Chhattisgarh State

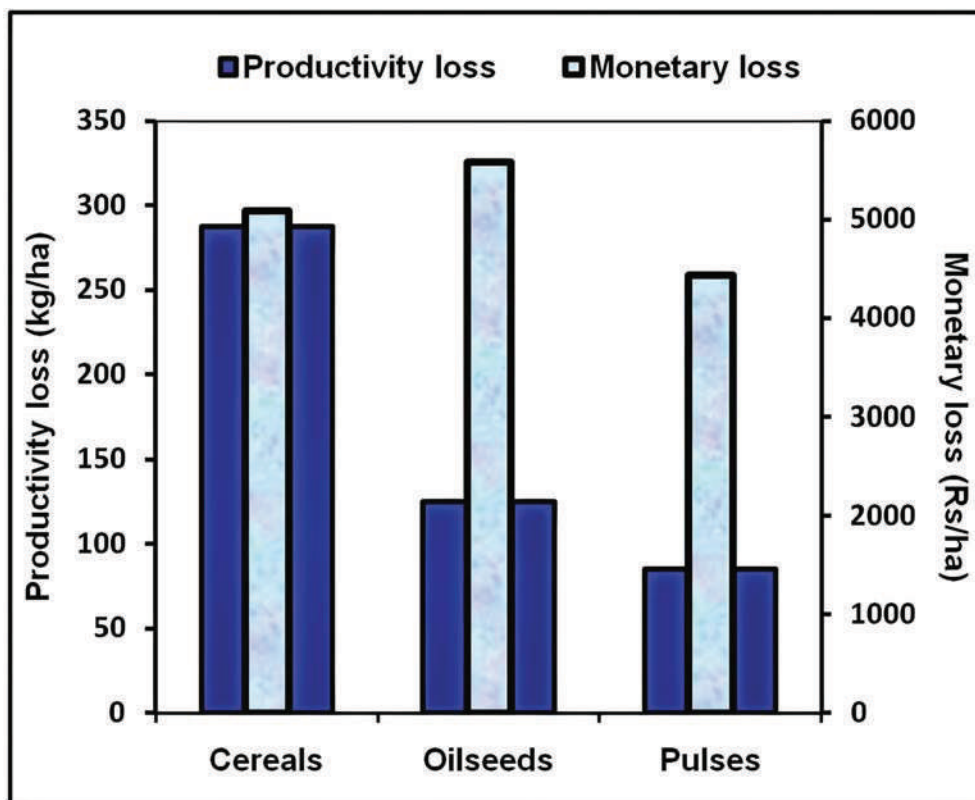


Fig. 4.5. Estimated productivity (kg ha^{-1}) and monetary loss (Rs ha^{-1}) of rainfed crops due to soil erosion in Chhattisgarh State

4.5 Area Under Risk and Treatment Measures

The analysis revealed that 41.27% of state's TGA falls under no treatment category as the soil loss in these areas is within the permissible limits, while 58.73% requires various degrees of soil erosion management due to high erosion rates. The distribution of TGA of the state under priority classes 1, 2, 3, 4, and 5 is 0.8, 28.5, 19.8, 8.2 and 3.7 %, respectively. The spatial distribution of priority areas under different classes is presented in Fig. 4.3.

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 and Table 4.4 which are given in the succeeding sections of the document. Table 4.2 which presents soil and water conservation measures, under different land situations, Table 4.3 presents district wise agronomic and vegetative measures and Table 4.4 presents district wise agro-forestry measures.

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

S. N.	District	TGA (000, ha)	Area under risk ('000 ha)	% of TGA	Special erosion problem	Conservation measures
Severity Risk –A						
1	Baloda Bazar	466.0	1.21(1:0.0, 2:1.21, 3: 0.0)	0.3	Drought*, Flood#, Heat waves#, Mining, Rill erosion Urbanization	Table 4.2 Sr No. 1.2, 1.3, 1.5, 2.8, 3.1.4, 3.2.3, 3.2.7, 4.3, 4.4, 5.5, 6.1.4, 6.1.6, 7.10,
2	Durg	229.5	2.07 (1:0.0, 2:0.0, 3: 2.07)	0.9	Drought#, Rill erosion, Urbanization Mining	Table 4.2 Sr No. 1.2, 1.5, 1.6, 1.7, 2.4, 2.5, 2.7, 3.1.4, 3.2.7, 4.3, 4.4, 4.6, 5.4, 5.6, 5.7, 6.1.7, 6.1.8, 6.2.6
3	Bemetara	286.0	6.36 (1:0.0, 2:0.0, 3: 6.36)	2.2	Drought*, Flood#, Rill erosion	Table 4.2 Sr No. 1.2, 1.5, 1.6, 1.7, 2.4, 2.5, 2.7, 4.3, 4.4, 4.6, 5.4, 7.1, 7.10
4	Janjgir Champa	385.5	20.93 (1:0.0, 2:9.28, 3: 11.64)	5.4	Drought# Heat waves#, Urbanization	Table 4.2 Sr No. 1.2, 1.3, 1.5, 1.6, 2.4, 4.4, 4.6, 5.6, 7.6
	Total	1367.0	30.57	2.2		
Severity Risk –B						
5	Balod	336.9	72.21 (1:0.0, 2:33.54, 3: 38.67)	21.4	Drought*, Flood#, Heat waves#, Rill erosion, Urbanization	Table 4.2- Sr No. 1.2, 1.5, 1.6, 1.7, 2.4, 2.5, 2.7, 4.1, 4.3, 4.5, 4.6, 4.9, 5.6, 7.8

S. N.	District	TGA (000, ha)	Area under risk ('000 ha)	% of TGA	Special erosion problem	Conservation measures
6	Dhamtari	408.8	91.73 (1:0.0, 2:47.51, 3: 44.21)	22.4	Urbanization Stream bank erosion	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.7, 2.5, 2.6, 2.7, 3.2.7, 4.2, 4.5, 4.6, 4.9, 5.2, 6.2.12, 7.7
7	Mahasamund	478.6	96.98 (1:0.0, 2:69.38, 3: 27.58)	20.3	Gully erosion, Open scrub	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 1.7, 2.4, 2.6, 2.7, 3.2.5, 4.3, 4.4, 4.8, 5.2, 6.2.8, 7.1, 7.4, 7.6
Total		1224.3	260.92	21.31		
Severity Risk –C						
8	Mungeli	276.5	104.14 (1:0.0, 2:91.85, 3: 12.28)	37.7	Drought* Deforestation, Heat waves#, Gully erosion	Table 4.2 Sr No.1.2, 1.4, 1.6, 2.4, 3.2.5, 4.1, 4.4, 5.4, 6.2.6, 7.1, 7.4, 7.7
9	Bilaspur	551.9	150.76 (1:0.0, 2:126.42, 3: 24.34)	27.3	Drought# Heat waves#, Deforestation, Mining	Table 4.2 Sr No. 1.2, 1.5, 1.6, 2.4, 2.7, 3.2.3, 4.5, 4.6, 5.3, 6.1.7, 6.2.9, 7.4, 7.11
10	Korba	658.8	194.73 (1:5.99, 2:106.88, 3: 81.86)	29.5	Mining Deforestation	Table 4.2 Sr No. 1.2, 1.3, 1.6, 1.7, 2.1, 2.4, 3.1.4, 3.2.3, 4.3, 4.4, 4.5, 5.2, 5.5, 6.1.1, 6.1.2, 6.1.9, 6.1.7, 7.7
11	Kabirdham	417.7	197.07 (1:0.0, 2:122.09,	47.2	Drought# Heat waves#, Deforestation	Table 4.2 Sr No. 1.2, 1.5, 1.6, 1.9, 1.10, 2.4, 2.5, 2.7,

S. N.	District	TGA (000, ha)	Area under risk ('000 ha)	% of TGA	Special erosion problem	Conservation measures
			3: 74.97)			3.2.3, 4.1, 4.3, 4.6, 4.5, 4.6, 5.3, 5.7, 6.1.7, 6.2.7
12	Gariyaband	485.2	233.90 (1:0.035, 2:137.75, 3: 96.11)	48.2	Gully erosion, Open scrub, Mining	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 2.4, 2.5, 2.7, 3.1.3, 4.3, 4.4, 5.3, 5.4, 6.1.4, 6.1.7, 6.2.7, 7.4, 7.6, 7.7
13	Dantewara	310.1	252.69 (1:0.0, 2:115.20, 3: 137.49)	81.5	Mining Gully erosion, Deforestation	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 1.8, 2.2, 2.4, 2.7, 3.1.1, 3.2.1, 3.2.6, 3.3.1, 3.3.6, 4.1, 4.3, 5.1, 5.2, 5.5, 6.1.5, 6.1.7, 6.2.7, 7.4, 7.6, 7.12
14	Raj Nandgaon	807.2	262.77 (1:1.70, 2:106.38, 3: 154.68)	32.6	Drought [#] Heat waves [#] , Deforestation, Urbanization	Table 4.2 Sr No. 1.2, 1.5, 1.6, 1.9, 1.10, 2.4, 2.5, 2.7, 3.2.3, 4.1, 4.3, 4.4, 4.5, 4.6, 5.5, 5.6
15	Surguja	399.6	285.51 (1:0.0, 2:109.19, 3: 176.31)	71.5	Drought [#] Frost Gully erosion, Coal Mining	Table 4.2 Sr No. 1.2, 1.3, 1.8, 2.4, 2.7, 3.1.2, 3.2.3, 3.2.6, 3.3.1, 4.3, 4.4, 5.5, 6.1.3, 6.1.7, 6.2.8,
16	Sukma	548.2	335.53 (1:0.0, 2:41.69, 3: 293.83)	61.2	Mining Gully erosion, Deforestation	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 1.8, 2.2, 2.4, 2.7, 3.1.1, 3.2.1, 3.2.6, 3.3.6, 4.1, 4.3, 5.4,

S. N.	District	TGA (000, ha)	Area under risk ('000 ha)	% of TGA	Special erosion problem	Conservation measures
						5.5, 6.1.4, 6.1.7, 6.2.7, 7.4, 7.6, 7.12
17	Narainpur	420.6	347.73 (1:0.0, 2:315.41, 3: 32.33)	82.7	Deforestation Gully erosion, Mining	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.8, 2.4, 2.6, 3.1.1, 3.2.3, 3.2.7, 3.3.6, 4.1, 4.3, 4.4, 5.1, 5.4, 5.7, 6.1.6, 6.2.8, 7.4, 7.6
18	Kondagaon	509.3	361.49 (1:0.0, 2:210.72, 3: 150.77)	70.9	Deforestation Gully erosion,	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.8, 2.5, 3.1.1, 3.2.1, 3.2.6, 3.3.6, 4.1, 4.3, 4.4, 5.2, 5.4, 6.1.7, 6.2.8, 6.2.9, 7.4, 7.7
19	Balrampur	625.3	372.09 (1:2.79, 2:104.11, 3: 265.19)	59.5	Drought [#] Heat waves	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 2.7, 3.1.4, 4.5, 4.6, 5.1, 5.5, 6.1.7, 7.7
20	Surajpur	543.3	377.87 (1:0.0, 2:262.80, 3: 115.06)	69.5	Heat waves Drought [#]	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 2.7, 3.1.4, 4.5, 4.6, 5.1, 5.5, 6.1.7, 7.7
21	Bastar	527.4	412.62 (1:0.71, 2:318.19, 3: 93.71)	78.2	Gully erosion, Deforestation	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.8, 2.5, 3.1.1, 3.2.1, 3.2.6, 3.3.6, 4.1, 4.3, 4.4, 5.2, 5.4, 6.1.7, 6.2.8, 6.2.9, 7.4, 7.7
22	Jashpur	585.6	416.10 (1:0.25, 2:294.31,	71.0	Drought [#] Sand mining	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 1.7, 1.8, 2.4, 2.7,



S. N.	District	TGA (000, ha)	Area under risk ('000 ha)	% of TGA	Special erosion problem	Conservation measures
			3: 121.53)			3.1.4, 4.3, 4.4, 5.1, 6.1.7, 6.1.8, 7.7
23	Korea	658.3	439.72 (1:0.0, 2:374.69, 3: 65.03)	66.8	Deforestation, Mining	Table 4.2 Sr No. 1.1, 1.2, 1.6, 2.4, 2.7, 3.2.3, 4.5, 4.6, 5.4, 6.1.7, 6.2.5, 6.2.12, 7.6, 7.7
24	Raigarh	705.5	445.97 (1:0.41, 2:400.85, 3: 44.70)	63.2	Mining, Heat waves	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.4, 3.1.4, 3.2.5, 4.1, 4.2, 4.6, 5.2, 5.6, 6.1.7, 7.1, 7.7
25	Kanker	689.1	453.51 (1:0.0, 2:222.32, 3: 231.18)	65.8	Deforestation Gully erosion, Mining	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.8, 2.4, 2.6, 3.1.1, 3.2.3, 3.2.7, 3.3.6, 4.1, 4.3, 4.4, 5.1, 5.4, 5.7, 6.1.6, 6.2.8, 7.4, 7.6
26	Bijapur	917.8	604.00 (1:0.14, 2:224.88, 3: 378.98)	65.8	Deforestation Gully erosion, Mining	Table 4.2 Sr No. 1.2, 1.3, 1.4, 1.8, 2.4, 2.6, 3.1.1, 3.2.3, 3.2.7, 3.3.6, 4.1, 4.3, 4.4, 5.1, 5.4, 5.7, 6.1.6, 6.2.8, 7.4, 7.6
	Total	10637.6	6248.20	58.73		

*Frequent occurrence# occasional occurrence

Table-4.2: Proposed 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%, 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	Fodder/ tea/ medicinal-aromatic crops on the 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: Vetiver grass (<i>Vetiveria zizanoides</i>); Guatemala grass (<i>Tripsacum laxum</i>); Weeping love grass (<i>Eragrostis curvula</i>); Lemon grass (<i>Cymbopogon citrates</i>); Roshal/palma rosa grass (<i>C. martinii</i>); Malabar (<i>C. flexuosus</i>); Hybrid Napier; Agave (<i>Agave Americana</i> & <i>Agave sisalana</i>); Geranium (<i>Pelargonium graveolens</i>); Mulberry (<i>Morus alba</i>); Pineapple (<i>Ananas comosus</i>)					
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)	✓	✓	✓	✓
3.1.4	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 (BWCD)		✓		✓
4.4	Loose boulders check dam (LBCD)		✓		✓
4.5	Gabion check dam		✓		✓
4.6	RR 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/Ooranies	✓	✓	✓	
5.2	Embankment pond		✓		
5.3	Pond renovation & Desilting	✓	✓	✓	
5.4	Farm pond-Dugout	✓		✓	
5.5	Subsurface runoff collection wells			✓	
5.6	Pond lining	✓	✓	✓	
5.7	Roof top water harvesting	✓		✓	
5.8	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 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 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 dams		✓		✓
7.7	Alternate land use system/Agroforestry		✓		✓
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		✓		✓

Note 1: The agronomic and vegetative measures and agro-forestry measures for Chhattisgarhis presented in table 4.3 **Note 2:** For concept, design and estimates of soil and water conservation measures, kindly refer, Mishra, P. K., Jua, 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:** Agro-forestry measures for Chhatisgarh is given in table 4.4

*Frequent occurrence# occasional occurrence

Table 4.3 District wise agronomic and vegetative soil and water conservation (SWC) measures proposed for the state of Chhattisgarh

[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 barriers Grasses/Fodder/Mechanical-Aromatic Crops) Vegetative
			Special problem area: Shelter belts and wind breaks, LBCD, BWCD, Recharge pits. Site specific mechanical measures Grassed waterways/Afforestation and bamboo plantation in Mine spoil area
Severity Risk: A			
1.	District: Baloda Bazar, TGA:466.0, A(Er): 1.21 (2:1.21), Er (%):0.3, Sp.P: Drought* flood#, heat waves#, mining and rill erosion		
	Relay cropping of Rice- lathyrus/ linseed/gram/ green gram Green gram-horse gram/nigerseed Mixed or intercropping of pigeonpea and green gram (4:2) or sesamum and green gram (4:2)	Green gram and cow pea are cultivated as green manuring crops. Inter tilling for soil mulch Mulching with paddy straw or use plastic mulch or other locally available material Cover crops –Green gram, field pea, cow pea Inter tilling for soil mulch, Mulching with Paddy straw/locally available materials	Horticulture/plantation crops like mango, papaya, banana Fodder crops such as napier grass, berseem and lucerne./mango/papaya/guava/drum stick/custard apple/ lemon/ water melon or mulsk melon/ draagon fruit etc.)
2.	District: Durg, TGA: 229.5, A(Er):2.07 (3: 2.07), Er(%):0.9, Sp.P: Drought, rill erosion, urbanization, mining	Clusterbean and blackgram are	Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Kharif</i> for regular sowing of <i>Rabi</i> crops SWC measures: -Brush wood and Loose boulder check dam. Afforestation with <i>Terminalia arjuna</i> , <i>Gmelina arboria</i> , <i>Acacia spp.</i> , <i>Albizia lebbek</i> , <i>Azadirachta indica</i> , <i>Dalbergia sissoo</i> , <i>Lannea coromandelica</i> , <i>Parkinsonia aculeate</i> , <i>Pongamia pinnata</i> , <i>Tecoma undulata</i> , <i>Tamarix articulata</i> , <i>Eucalyptus spp.</i> , <i>Tectona grandis</i> , <i>Dendrocalamus asper</i> , <i>D strictus</i> , <i>Bambusa nutans</i>
	Rice- Mahamaya, swarnasub 1, jaladubi, masuri- black gram /	Horticultural crops such as mango, banana, citrus, guava, papaya, beretc.	Mechanical measure: compartmental bunding, recharge

	<p>greengram Rice-pigeon pea/groundnut Soybean-chickpea/lentil/sunflower/safflower</p>	<p>cultivated as green manuring and cover crops.</p>	<p>Aromatic and medicinal crops: - lemon grass <i>E. citrifolia</i>, pauchauli, palmarosa] <i>Aloe vera</i></p>	<p>pit, nala bunds DLT measures: - LBCD, BWCD, RR checkdam Water harvesting structures: - roof top water harvesting Mining: Afforestation of mining areas and community land with suitable local tree species like bamboo, <i>Pongamia pinnata</i>, neem etc.</p>
<p>3.</p>	<p>District: Bemetara, TGA: 286.0, A(Er): 6.36 (3: 6.36), Er(%): 2.2, Sp.P: Drought, flood, rill erosion</p> <p>Rice-pigeon pea/groundnut/mustard Intercropping of pigeon pea + groundnut (2 : 5) Pigeon pea + sesamum (2:4) Maize + Cow pea (2:2)</p>	<p>Legume crops such as green gram and cow pea cultivated as cover crop, sunhemp and dhaincha are cultivated as green manuring crops</p>	<p>Horticulture/ plantation crops like guava, papaya, custard apple, mango, citrus</p>	<p>BWCD, LBCD, RR check dam, Water harvesting structure: - Farm pond dugout, Rill erosion:- bio fencing, boribund check dam Afforestation with <i>T. arjuna</i>, <i>G. arboria</i>, <i>A. lebbek</i>, <i>A. indica</i>, <i>D. sisso</i>, <i>L. coromandelica</i>, <i>P. aculeate</i>, <i>P. pinnata</i>, <i>T. undulata</i>, <i>T. grandis</i>, <i>D. strictus</i>.</p>
<p>4.</p>	<p>District: Janjgir Champa, TGA: 385.5, A(Er): 20.93(2:9.28, 3: 11.64), Er (%): 5.4, Sp.P: Drought, heat waves</p> <p>Crop rotation: - Rice (Sawarna, Jaldubi Mahamaya) – green gram/ balak gram/ horse gram/ lathyrus / linseed Rice/pea-wheat/ horse gram/ niger/ toria/ Maize+ pigeon pea (4:2) Groundnut (Var SB-11, JL-24)- fallow Summer Rice-prefer short duration variety-pigeon pea/ groundnut soyabean chickpea/ lentil/ sunflower/sesame/maize</p>	<p>Green gram and cow pea as cover crop for improving soil fertility, In-situ soil water conservation measures, opening of conservation furrows</p>	<p>Horticulture crops like cashewnut, mango, jack fruit, lemon, ber, improved jute cultivation, safflower, sunflower</p>	<p>Vegetative measures: - Afforestation/ reforestation DLT Treatments: - WBCD, LBCD, RR check dam, Water harvesting structures: - roof top water harvesting Afforestation with native species <i>G. arboria</i>, <i>A. lebbek</i>, <i>A. indica</i>, <i>D. sisso</i>, Gully control with bamboo spp.</p>



Severity Risk- B			
5	District: Balod, TGA: 336.9, A(Er): 72.21 (2:33.54, 3: 38.67), Er (%): 21.4, Sp.P: Drought, flood, heat waves, rill erosion	<p>Horticulture/plantation crops like mango, papaya, banana.</p> <p>Fodder crops such as napier grass, berseem and lucerne.</p>	<p>Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Kharif</i> for regular sowing of <i>Rabi</i> crops</p> <p>SWC measures: -Brush wood and Loose boulder check dam.</p> <p>Afforestation with <i>A. lebbek</i>, <i>A. indica</i>, <i>D. sisso</i>, <i>L. coromendelica</i>, <i>P. aculeate</i>, <i>P. pinnata</i>, <i>T. undulata</i>, <i>T. grandis</i>, <i>D. strictus</i>.</p>
6	District: Dhamtari, TGA: 408.8, A(Er): 91.73 (2:47.51, 3: 44.21), Er(%): 22.4, SP, PE: Urbanization and stream bank erosion	<p>Green gram and cow pea are cultivated as green manuring crops.</p> <p>Inter tilling for soil mulch, mulching with paddy straw or use plastic mulch or other locally available material</p>	<p>Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Kharif</i> for regular sowing of <i>Rabi</i> crops, silt detention tank, embankment pond, boundary agroforestry systems.</p> <p>SWC measures: - Brush wood and loose boulder check dam.</p> <p>Stream bank stabilization with <i>Bamboo spp.</i></p> <p>Afforestation with <i>A. indica</i>, <i>D. sisso</i>, <i>L. coromendelica</i>, <i>P. aculeate</i>, <i>P. pinnata</i>, <i>T. undulata</i>, <i>T. grandis</i>.</p>

7	<p>District: Mahasamund, TGA:478.6, A(Er): 96.98(2:69.38, 3: 27.58), Er(%):20.3, Sp.P: Gully erosion and open scrub</p> <p>Relay cropping of Rice (Var.:Mahamaya, Indira sona, Bameshwari) - lathyrus/ linseed/ gram/ green gram Green gram-horse gram/nizer Sesamum-nizer, rice-wheat/ groundnut Mixed or intercropping of pigeonpea and green gram(4:2) or sesamum and green gram (4:2)</p>	<p>Green gram and cow pea are cultivated as green manuring crops. Adopting zero tillage technique/Inter tilling for soil mulch Mulching with paddy straw or use plastic mulch or other locally available material</p>	<p>Horticulture/plantation crops like mango, citrus vegetables (coriander & garlic and onion) Fodder crops such as napier grass, berseem and lucerne. Mango/guava/drum stick/custard apple/bhel/ber/lemon, Water melon or musk melon/ dragon fruit etc.,</p>	<p>Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Kharif</i> for regular sowing of <i>Rabi</i> crops SWC measures: -Bio fencing with bamboo, brush wood and loose boulder check dam. Afforestation with <i>T. arjuna</i>, <i>G arboria</i>, <i>A lebbek</i>, <i>A. indica</i>, <i>L. coromendelica</i>, <i>P. pinnata</i>, <i>T undulata</i>, <i>Tamarix articulata</i>, <i>Eucalyptus spp.</i>,</p>
Severity Risk- C				
8	<p>District: Mungeli, TGA:276.5, A(Er):104.14(2:91.85, 3: 12.28), Er(%):37.7, Sp.P:Drought*Deforestation, Heat waves#, Gully erosion</p> <p>Cropping pattern: -Rice:-gram/sunflower/ linseed Rice-lathyrus Rice- pulses/oilseeds</p>	<p>Pueraria and calopogonium are used as cover crops. M u l c h i n g , i n t e r c u l t u r a l operations, foliar application of nutrients</p>	<p>Horticultural crops like mango, banana, papaya,Bhel/Bersweet potato, guvava, leafy vegetable Fodder crops such as napier grass, berseem, lucerne.</p>	<p>Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Kharif</i> for regular sowing of <i>Rabi</i> crops SWC measures: - Water absorption trenches, earthen check dam, LBCD, farm pond-dugout, nala bund. Gully erosion: - Bio fencing, safe disposal of water from gully head, Agroforestry Afforestation with <i>T. arjuna</i>, <i>G. arboria</i>, <i>A lebbek</i>, <i>A. indica</i>, <i>L.coromendelica etc.</i></p>



<p>9 District: Bilaspur, TGA:385.63, C: 150.76 (2:126.42, 3: 24.34), Er(%):39.09, Sp.P: Drought[#] Heat waves[#], Deforestation, Mining</p>	<p>Rice - Lehi system Line sowing method Poormima (105 days), Vanprabha (90 days), Danteshwari (105days). Madhuri (125 days) Kodo millet early variety like: JK-41 (90-100 days) JK-48 (90-105 days) GPUK-3 (90-105 days) Finger millet improved variety like: VR-708 (80-84 days) PES-400(90-92days)</p>	<p>Sunhemp and dhaincha are cultivated as green manuring crops and cowpea as cover crop.</p> <p>Cultivation of napier grass and lemon grass along the stream reduce erosion and napier grass augment fodder production to animals as well.</p> <p>Horticultural crops like banana, papaya, ber and jackfruit</p>	<p>Ridge and furrows, compartmental bunding, tied ridges SWC measures: Stream bank stabilization with bamboo and other species, contour staggered trenching, gabion check dam, RR check dam, pond renovation and desilting Mining: afforestation with <i>A. indica</i>, <i>D. sisso</i>, <i>L. coromendelica</i>, <i>P. aculeate</i>, <i>P. pinnata</i>, <i>T. undulata</i>, <i>T. grandis</i>.</p>
<p>10 District: Korba, TGA:658.8, A(Er):194.7(1:5.99, 2:106.88, 3: 81.86), Er(%):29.5, Sp.P: Mining Deforestation</p>	<p>Rice - Lehi system Line sowing method, Chandrahasini Vanprabha (90 days), Danteshwari (105days). Madhuri (125 days) Rice-Lathyrus Rice- Pulses (Black gram- Var Indira urd1, TU94-2: Pigon pea-var ICPL87, Rajivelochan) /oilseeds</p>	<p>Sunhemp and dhaincha are cultivated as green manuring crops. Cowpea as cover crop.</p> <p>Cultivation of napier grass and lemon grass along the stream reduce erosion and napier grass augment fodder production to animals as well.</p> <p>Horticultural crops like banana, papaya, ber and jackfruit</p>	<p>Ridge and Furrows, compartmental bunding SWC measures: Stream bank stabilization with bamboo and other species, contour staggered trenching, gabion check dam, RR check dam, pond renovation and desilting Mining: Vegetative hedge, turfing, application of geo textiles, afforestation with <i>A. indica</i>, <i>D. sisso</i>, <i>L. coromendelica</i>, <i>P. aculeate</i>, <i>P. pinnata</i>, <i>T. undulata</i>, <i>T. grandis</i>.</p>

11	<p>District: Kabirdham, TGA:417.7, A(Er):197.0(2:122.09, 3: 74.97), Er(%):47.2, Sp.P: Drought, Heatwaves, deforestation</p> <p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram</p> <p>Intercropping of pigeon pea/ soybean with maize black gram</p> <p>Intercropping of sugarcane with cash crop like spices toria& mustard</p>	<p>Inter tilling for soil mulch</p> <p>Mulching with paddy straw or use plastic mulch or other locally available material</p> <p>Maize and blackgram cultivated as fodder crop</p>	<p>Horticultural crops like mango, banana, guava, anola, papaya, vegetables, spices sweet potato</p> <p>Fodder crops such as napier grass, berseem, lucerne.</p>	<p>Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Kharif</i></p> <p>SWC measures: - Water absorption trenches, earthen check dam, LBCD, farm pond-dugout, nala bund</p> <p>Gully erosion: - Bio fencing, safe disposal of water from gully head, Agroforestry : Windbreak and shulter belts, and afforestation with native spp. like <i>T. arjuna</i>, <i>G. arboria</i>, <i>A lebbek</i>, <i>A. indica</i>, <i>L. coromendelica</i> etc.</p>
12	<p>District: Gariyaband, TGA:485.2, A(Er):233.9 (1:0.035, 2:137.75, 3: 96.11), Er(%):48.2, Sp.P: Gully erosion, Open scrub, mining</p> <p>Rice-Horse gram/ Niger / sesamum</p> <p>Relay cropping of Rice- lathyrus/ linseed/gram / green gram</p> <p>Sowing of <i>Rabi</i> crops Coriander (leaf), toria, linseed/ green gram (relay), lentil adopting zero tillage technique</p> <p>Mixed or intercropping of pigeon pea-green gram (4:2) or sesamum and green gram</p> <p>Sowing of sprouted seed (lai-chaupa) adopting lehi method of rice cultivation</p>	<p>Green gram and cow pea are cultivated as green manuring crops.</p> <p>Mulching with paddy straw or use plastic mulch or other locally available material</p>	<p>Horticulture/plantation crops like mango, papaya, banana/ lemon/ guava</p> <p>Fodder crops such as napier grass, berseem, lucerne.</p>	<p>SWC measures:- Silt detention tank, embankment pond, boundary agroforestry systems, brush wood and loose boulder check dam, pond renovation, stream bank stabilization with bamboo.</p> <p>Afforestation with <i>A. indica</i>, <i>D. sisso</i>, <i>L. coromendelica</i>, <i>P. aculeate</i>, <i>P. pinnata</i>, <i>T. undulata</i>, <i>T. grandis</i>.</p> <p>Mining areas : - Application of geotextiles, afforestation, bamboo plantation. turfing</p>



13	<p>District: Dantewara TGA: 310.1 A (Er): 252.69 (2:115.20, 3: 137.49), Er(%): 81.5, Sp.P: Gully erosion, mining deforestation</p> <p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram Maize (JM-216 (80-85 days), Chandan maize-1 (105 days), Chandansafed maize-2 (75 days)) + Pigeonpea (4:2) Kodo Kutki- Nizer/sunflower/ groundnut Finger millet:- VR-708 (80-84 days), PES-400(90-92days), Niger -Improved variety IGP-76(105-110 days) Kodo Millet:- Two intercropping operations at 15-20 DAS</p>	<p>B l a c k g r a m , horsegram and legumes are cultivated as green manuring and cover crops.</p> <p>Horticulture/plantation crops like cashew, mango, citrus, sapota, guvava, custard apple and banana Medicinal and aromatic:- Lemon and citrodora grass, <i>Aloe vera</i>, <i>Terminalia chebula</i>, <i>Phyllanthus emblica</i>, <i>Asparagus racemosus</i> etc. Industrial pulpwood crops</p>	<p>Farm pond and community pond for water storage/irrigation, Subsurface runoff collection wells, Earthen check dam and LBCD, Conservation bench terracing, Gabion drop structures For mining: - application of geotextiles, afforestation, bamboo plantation.</p>
14	<p>District: Rajnandgaon, TGA: 807.2, A(Er): 262.77 (1:1.70, 2:106.38, 3: 154.68), Er(%): 32.6%, Sp.P: Drought Heat waves, Deforestation and Urbanization</p> <p>Relay cropping of Rice-gram/ green gram/lathyrus /linseed Intercropping of Pigeon pea/soyabean with maize black gram Intercropping of sugarcane with cash crop like spices toria & mustard</p>	<p>Maize and balckgram cultivated as fodder crop inter tilling for soil mulch Mulching with paddy straw or use plastic mulch or other locally available material</p> <p>Horticultural crops like mango, banana, guava, lemon, custard apple,, papaya, vegetables, sweet potato, guvava Fodder crops such as napier grass, berseem, lucerne.</p>	<p>Compartmental bunding, ridge and furrows, tied ridges to conserve rainwater during <i>Khariif</i> SWC measures: - Water absorption trenches, earthen check dam, LBCD, Dugout farm pond, pond lining, roof top water harvesting, contour staggered trenches Agroforestry, windbreak and shelter belts, and afforestation with native spp. like <i>T.arjuna</i>, <i>G arboria</i>, <i>A lebbek</i>, <i>A. indica</i>, <i>L. coromandelica</i> etc.</p>

15	<p>District: Surguja, TGA: 399.6, A(Er):285.5 (2:109.19, 3: 176.31), Er(%):71.5, Sp.P:Drought# Frost, Gully erosion, Coal Mining</p> <p>Crop rotation: - Rice(Sawarna, Jaldubi Mahamaya) - Gram/ green gram/lathyrus /linseed Rice/wheat/pea-horsegram/Niger/Toria Groundnut (Var SB-11, JL-24)-fallow Sesamum (VarTC-25, JT-21)-Fallow</p>	<p>Inter cultivation (soil m u l c h i n g) , conservation tillage, linseed, groundnut and green gram and black gram cultivated as cover crops.</p>	<p>Horticulture/plantation crops like mango, banana, jackfruit, sapta, litchi and pear Plantation of lemon grass, <i>E.citridora</i> and other vegetables like potato and carrot</p>	<p>Drought: -Rain water harvesting structures, sub surface runoff collection wells, micro irrigation Gully erosion:- LBCD, BWCD, Gabion checkdam, RR checkdam For mining:- application of geotextiles, afforestation, bamboo plantation.</p>
16	<p>District: Sukma, TGA: 548.2, A(Er):335.5 (2:41.69, 3: 293.83), Er(%): 61.2, Sp.P: Mining, Gully erosion deforestation</p> <p>Intercropping maize (JM-216 , Chandansafed maize-2) +Pigon pea (4:2) Finger lillet (Indira Ragi1) +Sesamum (RT-54) Relay cropping : Rice –Maize/Niger/Lathyrus/ linseed/ gram/ green gram KodoKutki- Nizer (IGP-76) / sunflower /groundnut Mixed cropping: Kodo Millet, Little millet and Finger millet</p>	<p>Blackgram, sesamum, groundnut, horsegram and legumes are cultivated as green manuring and cover crops Inter cultivation (soil m u l c h i n g) , conservation tillage,</p>	<p>Horticulture/plantation crops like cashew, mango, citrus, sapota, guvava and custard apple Medicinal and Aromatic:- Lemon and citiodora grass, Aloe vera, <i>Terminalia chebula</i>, <i>Phyllanthus emblica</i>, Asparagus racemosus etc. Industrial pulpwood crops with <i>Eucalyptus spp.</i></p>	<p>Farm pond and community pond for water storage/irrigation, Gully erosion:- LBCD, BWCD, Gabion checkdam, RR check dam Conservation bench terracing Farm pond For mining: - application of geotextiles, afforestation, bamboo plantation.</p>
17	<p>District: Narayanpur, TGA: 420.6, A(Er):347.73 (2:315.41, 3: 32.33), Er(%): 82.7, Sp.P: Deforestation Mining, Gully erosion</p> <p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram Maize (Var: JM-216, Chandan maize-1, Chandansafed maize-2) + Pigeon pea (4:2) KodoKutki- Nizer/ sunflower/ groundnut</p>	<p>B l a c k g r a m , horsegram and legumes are cultivated as green manuring and cover crops Glyricidia and subabull in field bunds</p>	<p>Horticulture/plantation crops like cashew, mango, citrus, sapota, guvava, custard apple and banana Medicinal and aromatic:- Lemon and citiodora grass, Aloe vera, <i>T. chebula</i>, <i>P. emblica</i>, <i>A. racemosus</i> etc. Industrial pulpwood crops- <i>Eucalyptus spp.</i></p>	<p>Farm pond and community pond for water storage/irrigation, subsurface runoff collection wells, Grass water ways, earthen check dam, LBCD, BWCD, gabion check dam, RR checkdams,</p>



<p>Finger millet (Var:GPU28) with Pigeonpea (4:2) Niger (Var: Improved variety IGP-76) Kodo Millet (Var:Indirakodol, JK 155)</p>	<p>for green manure and fodder crop Inter cultivation (soil mulching), conservation tillage</p>		<p>conservation tillage bench terracing For mining: - application of geotextiles, afforestation, bamboo plantation.</p>
<p>18 District: Kondagaon, TGA: 509.3, A(Er):361.49 (2:210.72, 3: 150.77),Er(%): 70.9, Sp.P: Deforestation Gully erosion</p>			
<p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram Maize (Var: JM-216, Chandan maize-1, Chandansafed maize-2) + Pigeon pea (4:2) KodoKutki- Nizer/ sunflower/ groundnut Finger millet (Var:GPU28) with Pigeon pea (4:2) Low land: Rice with relay cropping Mid land: Maize/Finger millet+Pigeon pea intercropping Upland: Mixed cropping with finger millet</p>	<p>Inter cultivation (soil mulching), conservation tillage. black gram, horse gram and legumes are cultivated as green manuring and cover crops.</p>	<p>Horticulture/plantation crops like mango, citrus, cashew nut, sapota, guava, banana water melon and musk melon. Medicinal and aromatic:- <i>T. chebula</i>, <i>P. emblica</i>, <i>A. racemosus</i> etc. Industrial pulpwood crops- <i>Eucalyptus spp.</i> Intercropping cropping of ginger/ turmeric under mango orchards</p>	<p>Farm pond and community pond for water storage/irrigation, Subsurface runoff collection wells, Grass water ways, earthen check dam, LBCD, BWCD, gabion check dam, RR check dams, Conservation bench terracing For mining: - application of geotextiles, afforestation, bamboo plantation.</p>
<p>19 District: Balrampur, TGA:625.3, A(Er): 372.09 (1:2.79, 2:104.11, 3: 265.19),Er(%):59.5, Sp.P: Drought, Heat waves</p>			
<p>Crop rotation: - Rice (Sawarna, Jaldubi Mahamaya) - Gram/ green gram/lathyrus /linseed Rice/Wheat/Pea-horsegram/niger/toria Groundnut (Var SB-11, JL-24)- fallow Sesamum (VarTC-25, JT-21)- Fallow</p>	<p>Inter cultivation (soil mulching), conservation tillage, linseed, groundnut and green gram and black gram cultivated as cover crops.</p>	<p>Horticulture/plantation crops like mango, cashew nut, banana, jackfruit, sapota, litchi and vegetable crop like potato and onion Plantation of lemon grass, <i>E.citridora</i> and others. Collection of Mahua flowers & seeds</p>	<p>Drought: -Rain water harvesting structures, compartmental and field bunding, farm pond, micro irrigation Gully erosion:- LBCD, BWCD, gabion checkdam, RR checkdam Agroforestry, wind break and shelter belts with native tree species</p>

20	<p>District: Surajpur, TGA:625.3, A(Er):377.87 (1:0.0, 2:262.80, 3: 115.06), Er(%):59.5, Sp.P: Drought, Heat waves</p> <p>Crop rotation: - Rice(Sawarna, Jaldubi Mahamaya) - Gram/ green gram/lathyrus /linseed Rice/Wheat/Pea-Horsegram/Niger/Toria Groundnut (Var SB-11, JL-24)-fallow Sesamum (VarTC-25, JT-21)- Fallow</p>	<p>Inter cultivation (soil m u l c h i n g) , conservation tillage, linseed, groundnut and green gram and black gram cultivated as cover crops.</p>	<p>Horticulture/plantation crops like mango, cashew nut, banana, jackfruit, sapota, litchi and vegetable crop like potato and onion Plantation of lemon grass, <i>E.citridora</i> and others Collection of mahua flowers & seeds</p>	<p>Drought: -Rain water harvesting structures, compartmental and field bunding, farm ponds micro irrigation Gully erosion:- LBCD, BWCD, gabion gheckdam, RR checkdam agroforestry, windbreak and shelter belts with native tree species</p>
21	<p>District: Bastar, TGA:527.4, A(Er):412.6 (1:0.71, 2:318.19, 3: 93.71), Er(%):78.2, Sp.P:Gully erosion, Deforestation</p> <p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram Maize (Var: JM-216, Chandan maize-1, Chandansafed maize-2) + Pigeonpea (4:2) KodoKutki- Nizer/ sunflower/ groundnut Finger millet (Var:GPU28) with Pigeonpea (4:2) Niger (Var: Improved variety IGP-76) Kodo Millet(Var:Indirakodo1, JK 155)</p>	<p>Blackgram, horsegram and legumes are cultivated as green manuring and cover crops. Glyricidia and subabul in field bunds for green manure and fodder crop. Inter cultivation (soil mulching), conservation tillage,</p>	<p>Horticulture/plantation crops like cashew, mango, citrus, sapota, guvava, custard apple, shaded coffee and banana Medicinal and aromatic:- Lemon and citiodora grass, Aloe vera, <i>T. chebula</i>, <i>P. emblica</i>, <i>A. racemosus</i> etc. Industrial pulpwood crops- <i>Eucalyptus spp.</i></p>	<p>Farm pond and community pond for water storage/irrigation, subsurface runoff collection wells, Grass water ways, earthen check dam, LBCD, BWCD, gabion check dam, RR checkdams, Conservation bench terracing For mining: - application of geotextiles, afforestation, bamboo plantation.</p>
22	<p>District: Jashpur, TGA:585.6,A(Er):416.1(1:0.25, 2:294.31, 3: 121.53),Er(%):71, Sp. P: Gully erosion, Drought sand mining</p> <p>Crop rotation: - Rice(Sawarna, Jaldubi Mahamaya) - Gram/ green gram/lathyrus /linseed Rice/wheat/pea-horse gram/niger/toria Groundnut (Var SB-11, JL-24)-fallow Sesamum (VarTC-25, JT-21)- Fallow</p>	<p>Inter cultivation (Soil m u l c h i n g) , conservation tillage, linseed, groundnut and green gram and black gram cultivated as cover crops.</p>	<p>Horticulture/Plantation crops like mango, cashew nut, coffee, tea, strawberry, pear, apple, jackfruit, sapota, litchi and potato Plantation of lemon grass, <i>E.citridora</i> and others Collection of Mahua flowers & seeds</p>	<p>Drought: -Rain water harvesting structures, contour cultivation, farm ponds, micro irrigation, staggered trenching. Gully erosion:- LBCD, BWCD, gabion checkdam, RR checkdam, stream bank stabilization with grasses Agro-horti system</p>



<p>23 District: Korea, TGA:658.3, A(Er):439.72(2:374.69, 3: 65.03), Er (%):66.8, Sp. P: Deforestation and mining</p>	<p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram Maize (Var: JM-216, Chandan maize-1, Chandansafed maize-2) + Pigeon pea (4:2) KodoKutki- Nizer/ sunflower/ groundnut Finger millet (Var:GPU28) with Pigeon pea (4:2) Low land: Rice with relay cropping Mid land: Maize/Finger millet+Pigeon pea intercropping Upland: Mixed cropping with finger millet</p>	<p>Inter cultivation (soil m u l c h i n g) , conservation tillage linseed, groundnut and green gram and black gram cultivated as cover crops. Glyricidia and subabul in field bunds for green manure and fodder crop.</p>	<p>Horticulture/plantation crops like mango, cashew nut, banana, jackfruit, sapota, litchi, guava and vegetable crop like potato and onion Plantation of lemon grass, <i>E.citriodora</i> and others collection of Mahua flowers & seeds Medicinal plants like lemon grass, khus grass, <i>E. citriodora</i> Industrial pulp wood crops</p>	<p>Drought: -Rain water harvesting structures, compartmental and field bunding, farm ponds Micro irrigation Gully erosion:- LBBCD, BWCD, gabion checkdam, RR checkdam Agroforestry, windbreak and shelter belts with native tree species</p>
<p>24 District: Raigarh, TGA:705.5, A(Er):445.9(1:0.41, 2:400.85, 3: 44.70), Er(%):63.2, Sp.P: Mining, gully erosion heat waves</p>	<p>Crop rotation: - Rice (Sawarna, Jaldubi Mahamaya) – green gram/ balak gram/ horse gram/ lathyrus / linseed Rice/Pea-Wheat/ horse gram/niger/ toria Maize+pigeon pea (4:2)Groundnut (Var SB-11, JL-24)- fallow Summer Rice -Prefer short duration variety-pigeon pea/groundnut Soybean chickpea/lentil/sunflower/ sesame/Maize</p>	<p>Green gram and cow pea as cover crop for improving soil fertility In-situ soil water conservation measures Opening of conservation furrows. Glyreedia and suabul in field bunds for green manure and fodder crop.</p>	<p>Horticulture crops like cashewnut, mango, jack fruit, lemon, ber, Improved jute cultivation, safflower, sunflower</p>	<p>Vegetative measures: Afforestation/reforestation DLT Treatments: - WBCD, LBBCD, RR check dam, water harvesting structures: - roof top water harvesting For mining: - application of geotextiles and bamboo plantation. Afforestation with native species <i>G. arborea</i>, <i>A. lebbek</i>, <i>A. indica</i>, <i>D. sisso</i>, gully control with bamboo spp.</p>

<p>25 District: Kanker, TGA:689.1, A(Er):453.5(2:222.32, 3: 231.18), Er(%): 65.8, Sp.P: Deforestation, gully erosion and mining</p>	<p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram. Maize (Var: JM-216, Chandan maize-1, Chandansafed maize-2) + Pigeonpea (4:2) KodoKutki- Nizer/ sunflower/ groundnut Finger millet (Var:GPU28) with Pigeonpea (4:2) Low land: Rice with relay cropping Mid land: Maize/Finger millet+Pigon pea intercropping Upland: Mixed cropping of millets</p>	<p>Inter cultivation (soil m u l c h i n g) , conservation tillage Black gram, horsegram and legumes are cultivated as green manuring and cover crops Glyricidia and subabul in field bunds for green manure and fodder crop.</p>	<p>Horticulture/plantation crops like mango, citrus, cashew nut, sapota, guava, banana, water melon and musk melon Medicinal and Aromatic:- <i>T. chebula</i>, <i>P. emblica</i>, <i>A. racemosus</i> etc Industrial pulpwood crops- <i>Eucalyptus spp.</i> Intercropping cropping of ginger/ turmeric under mango orchards</p>	<p>Farm pond and community pond for water storage/irrigation, subsurface runoff collection wells, Grass water ways, earthen check dam, LBCD, BWCD, gabion check dam, RR check dams, conservation bench terracing For mining: - application of geotextiles, afforestation, bamboo plantation.</p>
<p>26 District: Bijapur, TGA:617.8, A(Er):604.0 (1:0.14, 2:224.88, 3: 378.98), Er(%): 97.7, Sp.P: Deforestation, gully erosion and mining</p>	<p>Relay cropping of Rice- lathyrus/ linseed/ gram/ green gram Maize (Var: JM-216, Chandan maize-1, Chandansafed maize-2) + Pigeonpea (4:2) KodoKutki- Nizer/ sunflower/ groundnut Finger millet (Var:GPU28) with Pigeonpea (4:2) Niger(Var: Improved variety IGP-76) Kodo Millet (Var:Indirakodo1, JK 155)</p>	<p>Black gram, horsegram and legumes are cultivated as green manuring and cover crops. Glyricidia and subabul in field bunds for green manure and fodder crop. Inter cultivation (soil m u l c h i n g) , conservation tillage,</p>	<p>Horticulture/plantation crops like cashew, mango, citrus, sapota, guvava, custard apple, coconut and banana Medicinal and aromatic:- Lemon and citronela, <i>E. citriodoras</i>, <i>Aloe vera</i>, <i>T. chebula</i>, <i>P. emblica</i>, <i>A. racemosus</i> etc. Industrial pulpwood crops- <i>Eucalyptus spp.</i></p>	<p>Farm pond and community pond for water storage/irrigation, subsurface runoff collection wells, Grass water ways, earthen check dam, LBCD, BWCD, gabion check dam, RR checkdams, Conservation bench terracing For mining: - application of geotextiles, turfing, afforestation, bamboo plantation.</p>
<p>Note: Severity risk A d² 50,000 ha area is critical; Severity risk B= between 50,000:1,00000 ha area is critical; Severity risk C e³ 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_p: TL); 1: (E_p: TL) >35 t ha⁻¹ yr⁻¹; 2: (E_p: TL) in the range of 25:35 t ha⁻¹ yr⁻¹; 3: (E_p: TL) in the range of 15:25 t ha⁻¹ yr⁻¹. Table 4.1 represents different soil and water conservation measures for different land situations and Table 4.4 represents district wise potential agroforestry systems (AFS)</p>				

Table 4.4 Agroforestry solution (AFS) for soil and water conservation in Chhattisgarh

S. N.	Agro-climatic Zone	Districts	AFS for arable lands	AFS for non-arable lands	Special problem area (Mining/gully/open scrub)
1	Northern Hills	Korea, Surguja, Jashpur, Raigarh, Surajpur, Balarampur	<p>Agri-horticulture (block/boundary plantations) - Mango (<i>Mangifer indica</i>), amla (<i>Phyllanthus emblica</i>), Lemon (<i>Citrus limon</i>), Bhel (<i>Aegle marmelos</i>), Drum stick (<i>Moringa oleifera</i>), Jamoon (<i>Syzygium cumini</i>), Jack fruit (<i>Artocarpus heterophilus</i>), Dragon fruit (<i>Selenicereus undatus</i>), Litchi (<i>Litchi chinensis</i>), Pear (<i>Pyrus communis</i>), Peach (<i>Prunus persica</i>), Plum (<i>Prunus domestica</i>) <i>Passion fruit (Passiflora edulis)</i>.</p> <p>Agri-silviculture - traditional boundary plantation; <i>Butea monosperma</i>, <i>Pongamia pinnata</i>, <i>Gmelina arborea</i>, <i>Eucalyptus</i> spp., <i>Tectona grandis</i>, <i>Shorea robusta</i>, <i>Dalbergia sisso</i>, <i>Artocarpus heterophilus</i> and <i>Buchanania longana</i></p> <p>Medicinal and Aromatic AFS system: <i>Cymbopogon flexuosus</i> (Lemon), <i>Eucalyptus citriodora</i>, <i>Aloe vera</i>, <i>T. chebula</i>, <i>P. emblica</i>, <i>A. racemosus</i> etc.</p>	<p>Silvi-pastoral system: Native grasses under scattered native trees such as Teak (<i>Tectona grandis</i>), Sal (<i>Shorea robusta</i>), Bija (<i>Pterocarpus marsupium</i>), Saja (<i>Terminalia tomentosa</i>), Dhavdha (<i>Anogeissus latifolia</i>), Mahua (<i>Madhuca indica</i>) and Tendu (<i>Diospyros melanoxylon</i>) Char; <i>Buchanania longana</i> etc., Monoculture of <i>Anacardium occidentale</i>, <i>Dalbergia sissoo</i> with conservation measures</p> <p>Enrichment planting of degraded / scattered forest areas with the native trees species such as <i>Terminalia arjuna</i>, <i>Gmelina arborea</i>, <i>Acacia</i> spp., <i>Albizia lebbek</i>, <i>Azadirachta indica</i>, <i>Dalbergia sissoo</i>, <i>Lannea coromendelica</i>, <i>Tecoma undulata</i>, <i>Tamarix articulata</i>, <i>Eucalyptus</i> spp., <i>Tectona grandis</i>, <i>Bambusa nutans</i>.</p>	<p>Afforestation/enrichment planting/gully control: Planting of area with following species. <i>Terminalia arjuna</i>, <i>Gmelina arborea</i>, <i>Acacia</i> spp., <i>Albizia lebbek</i>, <i>Azadirachta indica</i>, <i>Dalbergia sissoo</i>, <i>Lannea coromendelica</i>, <i>Parkinsonia aculeate</i>, <i>Pongamia pinnata</i>, <i>Tecoma undulata</i>, <i>Tamarix articulata</i>, <i>Eucalyptus</i> spp., <i>Tectona grandis</i>, <i>Dendrocalamus asper</i>, <i>D strictus</i>, <i>Bambusa nutans</i>, <i>Bambusa arundinacea</i>, <i>Terminalia catappa</i>, <i>Butea monosperma</i>, <i>Pongamia pinnata</i>, <i>Madhuca indica</i>, <i>Bahunia verigata</i></p> <p>Legume covers: <i>Desmanthus virgatus</i>, <i>Cassia tora</i>, <i>Cassia occidentalis</i>, <i>Stylosanthes hamate</i>, <i>Mucuna pruriens</i>, <i>Tephrosia purpurea</i></p> <p>Preventing firewood collection from open scrub and protection against annual bushfire</p> <p>Biofencing plantation: <i>Agave americana</i>, <i>Acacia pendata</i> etc.</p>

S. N.	Agro-climatic Zone	Districts	AFS for arable lands	AFS for non-arable lands	Special problem area (Mining/gully/open scrub)
2	Central plains	Balota – Bazar, Durg, Bemētara, Janjgir-Champa, Balod, Mungeli, Korba, Gariyaband, Billaspur, Kabirdham, Rajnandgoan, Dhamtari, Mahasamund,	<p>Agri-horticulture (block/ boundary plantations) - Mango (<i>Mangifera indica</i>), Guava (<i>Psidium guajava</i>), Lemon, (<i>Citrus limon</i>), Amla (<i>Phyllanthus emblica</i>), Bhel (<i>Aegle marmelos</i>), Dragon fruit (<i>Selenicereus undatus</i>), Drum Stick (<i>Moringa oleifera</i>), Jamoon (<i>Syzygium cumini</i>), Custard apple (<i>Annona squamosa</i>), Jack fruit (<i>Artocarpusheterophylus</i>), Sapota (<i>Achras sapota</i>) and Ber (<i>Ziziphus mauritiana</i>)</p> <p>Agri-silviculture- Traditional boundary plantation: <i>Tectona grandis</i>, <i>Terminalia paniculata</i>, <i>T. chebula</i>, <i>Morus alba</i>, <i>Gmelinavar borea</i>, <i>Dalbergia sisso</i>, <i>Butea monosperma</i>, <i>Pongamia pinnata</i>, <i>Eucalyptus tereticornis</i>, <i>Shorea robusta</i>, <i>Artocarpus heterophylus</i>, <i>Diospyros melanoxylon</i>, <i>Azadirachtaindica</i>, <i>Grevillea robusta</i></p> <p>Industrial pulpwood crops- <i>Eucalyptus camaldulensis</i>, <i>E. tereticornis</i>, <i>E. grandis</i>, <i>E. globulus</i> and <i>E. citriodora</i>.</p>	<p>Silvi-pastoral system: Native grasses under scattered native trees such as Teak (<i>Tectona grandis</i>), Sal (<i>Shorea robusta</i>), Bija (<i>Pterocarpus marsupium</i>), Saja (<i>Terminalia tomentosa</i>), Dhavdha (<i>Anogeissus latifolia</i>), Mahua (<i>Madhuca indica</i>) and Tendu (<i>Diospyros melanoxylon</i>)</p> <p>Char: <i>Buchanania longana</i>, <i>Palash</i> (<i>Butea monosperma</i>) etc.,</p> <p>Monoculture of Teak (<i>Tectona grandis</i>), Sal (<i>Shorea robusta</i>), Bija (<i>Pterocarpus marsupium</i>), Saja (<i>Terminalia tomentosa</i>), <i>Bambusa arundinacea</i>, <i>Albizia lebbek</i>, <i>A. odoratissima</i> <i>Albizia spp.</i> <i>Terminalia catappa</i></p>	<p>Afforestation/Enrichment planting/gully control: Planting of area with following species. <i>Terminalia arjuna</i>, <i>Gmelina arboria</i>, <i>Acacia spp.</i>, <i>Albizia lebbek</i>, <i>Azadirachta indica</i>, <i>Dalbergia sissoo</i>, <i>Lannea coromandelica</i>, <i>Pongamia pinnata</i>, <i>Tamarix articulata</i>, <i>Eucalyptus spp.</i>, <i>Tectona grandis</i>, <i>Dendrocalamus asper</i>, <i>D strictus</i>, <i>Bambus anutans</i>, <i>Bambusa arundinacea</i>, <i>Terminalia catappa</i>, <i>Butea monosperma</i>, <i>Pongamia pinnata</i>, <i>Madhuca indica</i>, <i>Ficus drupaceae</i>, <i>Prosopis juliflora</i>, <i>Prosopis pallida</i>, <i>Dodonaea viscosa</i>, <i>Cassia auriculata</i>.</p> <p>Biofencingplantation: <i>Agave americana</i>, <i>Acacia pendata</i> etc.</p> <p>Preventing firewood collection from open scrub and protection against annual bushfire</p>

S. N.	Agro-climatic Zone	Districts	AFS for arable lands	AFS for non-arable lands	Special problem area (Mining/gully/open scrub)
3	Bastar plateau	Kanker, Baster, Dantewada, Sukma, Naayanpur, Bijapur, Kondagoan	<p>Agri-horticulture (block/ boundary plantations) - Cashewnut (<i>Anacardium occidentale</i>), Mango (<i>Mangifera indica</i>), Bhel (<i>Aegle marmelos</i>), Amla (<i>Phyllanthus emblica</i>), Coffee (<i>Coffea robusta</i>), Custard apple (<i>Annona squamosa</i>), Drum Stick (<i>Moringa oleifera</i>), Jamoon (<i>Syzygium cumini</i>), Jack fruit (<i>Artocarpus heterophyllus</i>) and Sapota (<i>Achrasapota</i>).</p> <p>Medicinal and Aromatic AFS system: Arrow root (<i>Maranta arundinacea</i>), Shatavari (<i>Apseragus recemosa</i>) Lemon grass (<i>Cymbopogon flexosus</i>), Citriodora (<i>Eucalyptus citriodora</i>), <i>T. chebula</i>, <i>P. emblica</i>, <i>T. bellarica</i> etc.</p> <p>Agri-silviculture- Traditional boundary plantation: <i>Tectona grandis</i>, <i>Terminalia</i> spp., <i>Morus alba</i>, <i>Gmelina arborea</i>, <i>Dalbergiasisso</i>, <i>Butea monosperma</i>, <i>Pongamia pinnata</i>, <i>Eucalyptus tereticornis</i>, <i>Shorea robusta</i>, <i>Artocarpus heterophyllus</i>, <i>Diospyros melanoxylon</i>, <i>Azadirachta indica</i>, <i>Grevillea robusta</i></p> <p>Industrial pulpwood crops-<i>Eucalyptus camaldulensis</i>, <i>E. tereticornis</i>, <i>E. grandis</i>, <i>E. globulus</i> and <i>E. citriodora</i>.</p>	<p>Monoculture of Teak (<i>Tectona grandis</i>), Sal (<i>Shorea robusta</i>), Bija (<i>Pterocarpus marsupium</i>), <i>Bambusa arundinacea</i>, <i>Albizia lebbek</i>, <i>A. Odoratissima albizzia</i> spp. <i>Terminalia catappa</i></p> <p>Silvi-pastoral system: Native grasses under scattered native trees such as Sal (<i>Shorea robusta</i>), Teak (<i>Tectona grandis</i>), Bija (<i>Pterocarpus marsupium</i>), Saja (<i>Terminalia tomentosa</i>), Dhavdha (<i>Anogeissus latifolia</i>), Mahua (<i>Madhuca indica</i>) and Tendu (<i>Diospyros melanoxylon</i>) <i>Char</i>; (<i>Buchanania longana</i>), <i>Palash</i> (<i>Butea monosperma</i>) etc.,</p>	<p>Afforestation/Enrichment planting/gully control: Planting of area with following species. <i>Tectona grandis</i>, <i>Dendrocalamus asper</i>; <i>D strictus</i>, <i>Bambusa nutans</i>, <i>Bambusa arundinacea</i>, <i>Terminalia catappa</i>, <i>Butea monosperma</i>, <i>Terminalia arjuna</i>, <i>Gmelina arborea</i>, <i>Albizia lebbek</i>, <i>Azadirachta indica</i>, <i>Dalbergia sissoo</i>, <i>Lannea coromandelica</i>, <i>Pongamia pinnata</i>, <i>Tamarix articulata</i>, <i>Pongamiapinnata</i>, <i>Madhuca indica</i>, <i>Cassia auriculata</i>.</p> <p>Biofencing plantation: <i>Agave americana</i>, <i>Acacia pendata</i> etc.</p> <p>Preventing firewood collection from open scrub and protection against annual bushfire</p> <p>Drainage line treatment with <i>Dendrocalamus asper</i>; <i>D strictus</i>, <i>Bambusa nutans</i>, <i>Bambusa arundinacea</i></p>



5.0

CONCLUSION

About 59.62% area of Chhattisgarh requires various degrees of soil erosion management. The total area under three priority classes (Class 1, 2 and 3) is 6540 thousand hectares out of which about 12.0 thousand hectares are under very high priority category (Priority class I). Bijapur (604 thousand hectares), Kanker (453 thousand hectares), Raigarh (445 thousand hectare), Korea (439 thousand hectare), Jashpur (416 thousand hectare) and Bastar (412 thousand hectares) districts are having the highest area which needs priority treatment for soil and water conservation. In some lateritic landforms, deep rills and gullies are observed. Other special problems include open scrub, gully erosion, mining, stream bank erosion and deforestation which warrant priority attention. A wide range of soil and water conservation measures for different land situations and agroforestry measures for different districts have been suggested. The district wise agronomic and vegetative measures, engineering measures and agroforestry measures suggested in the document aims at reducing soil erosion below the soil loss tolerance limit of the area. The priority area based on the prevalent erosion rate and soil loss tolerance limit 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.

6.0

REFERENCES

- Biswas, H., Raizada, A., Mandal, D., Kumar, S., Srinivas, S. and Mishra, P. K. 2015. Identification of areas vulnerable to soil erosion risk in India using GIS methods, *Solid Earth*, 6, pp1247–1257, doi:10.5194/se-6-
- Hombegowda, H. C., Kannan, K., Kumar, G., Mandal, D., Dogra, P., Kaushal, R. and Madhu, M. 2021. Soil erosion status, priority treatment areas and conservation measures for different districts of Kerala, ISBN-ISBN-978-81-92-4624-9-3, 26p.
- ICAR, 2010. Degraded and Wasteland of India – Status and Spatial Distribution. ICAR, New Delhi, pp 1–167 (by Maji, A.K., Reddy, G.P.O., and Sarkar, D).
- Jiayin, H., Baoan, H., Xiangjun, T., Jin, C. and Long, L. 2020. Concept and practice of open pit mining area restoration and reuse-taking an open-pit coal mining area in Datong, Shanxi as an example. In *E3S Web of Conferences* (Vol. 145p. 02014). EDP Sciences.
- Kannan, K., Hombegowda, H. C., Kumar, G., Mandal, D., Dogra, P., Kaushal, R. and Madhu, M. 2021. Soil erosion status, priority treatment areas and conservation measures for different districts of Tamil Nadu, ISBN-ISBN978-81-92-4624-4-8, 31p.
- Lal, R. 2011. Soil Carbon Sequestration. SOLAW Background Thematic Report- TR04B
- Mandal, D. and Giri, N. 2021. A brief history of soil erosion and conservation policy in India. *Current Science*. Vol:20(6):1007-1011
- Mandal, D., Giri, N. and Srivastava, P. 2020. The magnitude of erosion-induced carbon (C) flux and C-sequestration potential of eroded lands in India, *European Journal of Soil Science*, 72(2):pp151-168. <https://doi.org/10.1111/ejss.12886>
- NAAS. 2017. Mitigating land degradation due to water erosion. Policy Paper No. 88, NAAS, New Delhi, 20p.
- Pande, V. C., Kurothe, R. S., Sena, D. R. and Kumar, G. 2014. Cost of siltation in Sardar Sarovar reservoir: implications for catchment treatment, *Current Science*, 106:pp35-39
- Prasad, Y.G., Venkateswarlu, B., Ravindra Chary, G., Srinivasarao, Ch., Rao, K.V., Ramana, D.B.V., Rao, V.U.M., Subba Reddy, G. and Singh, A.K. (2012). Contingency Crop Planning for 100 Districts in Peninsular India. Central Research Institute for Dryland Agriculture, Hyderabad 500 059, India. 302p.

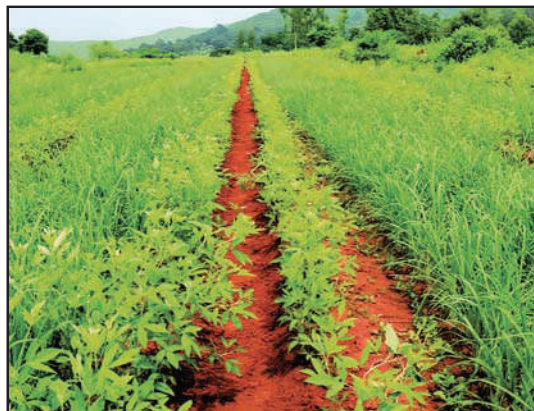


- Sharda, V.N. and Dogra, P. 2013. Assessment of productivity and monetary losses due to water erosion in rainfed crops across different states of India for prioritization and conservation planning. *Agricultural Research*, 2(4): pp382-392. DOI10.1007/s40003-013-0087-1.
- Sharda, V.N. and Mandal, D. 2018. Prioritization and Field Validation of Erosion risk are as for combating land degradation in north western Himalayas. *Catena*, 164:pp71-78.
- Sharda, V.N. and Ojasvi, P.R. 2016. A revised soil erosion budget for India: Role of reservoir sedimentation and land-use protection measures. *Earth Surf. Process. Landforms*, 41, pp2007-2023.
- Sharda, V.N., Dogra, Pradeep and Prakash, C. 2010. Assessment of production losses due to water erosion in rainfed areas of India. *Journal of Soil and Water Conservation*, 65(2): pp79-91.
- UNCCD, 2013. Achieving Land Degradation Neutrality at the country level Building blocks for LDN target setting, pp1-32
([https://www.unccd.int/sites/default/files/documents/160915_ldn_rgb_small%20\(1\).pdf](https://www.unccd.int/sites/default/files/documents/160915_ldn_rgb_small%20(1).pdf) accessed on 18th May, 2021)

Agronomic conservation measures for arable lands



Relay cropping of Rice- black gram



Inter cropping of Finger millet with Pigeon pea (6:2)



Alley cropping of finger millet with Gliricidia alley



Papaya cultivation under plastic mulching with horse gram as cover crop



Multitier coconut cropping system



Vegetable cultivation in the terrace land

Agroforestry practices / measures



Agro-silvi AFS with Teak



Live mulching with legumes in coconut plantation



Shelter belt and windbreak with Silver oak trees



Lemon grass with Mango AFS



Paired row Eucalyptus AFS



Relay AFS with Eucalyptus – Oil palm

Erosion control measures



Bio engineering (stonebunding+grass) measures



Live check dam for erosion control



Terrace cultivation with fodder grass in the raiser



Masonry check dam



Gabion check dam



Masonry diversion cum check dam



Dugout farm pond



Loose boulder check dam



Gully erosion control by geo jute with grass planting



Mucanabracteta cover crop



Geo jute cover with grass planting in mine spoiled areas



Trench-cum-half moon basin

Other production cum conservation measures



Trenching cum bunding



Inter cropping of Colocasia with Maize



Turmeric under Mango AFS



Paddy cultivation under well maintained terraces



Rubber check dam for seasonal water storage



Ginger under Mango AFS

Other production cum conservation measures



Green gram under *Melia dubia* AFS



Mixed cropping of Papaya with Marigold



**Shelter belt and windbreak with
Ginger+Mango**



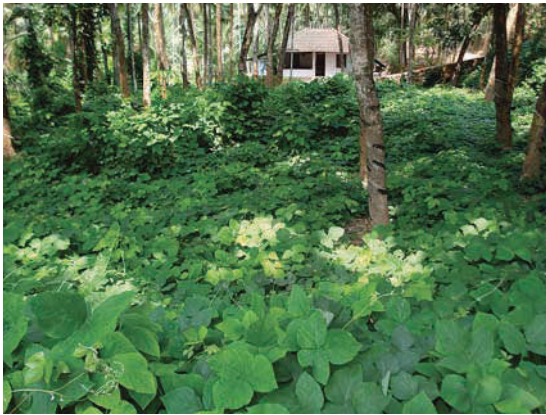
**Vegetables under terrace conservation
system**



Melia with stone mulching



Melia with trench swc



Cover crop of *Mucanabractata* in commercial plantation



Inter cropping of red gram with ginger



Multistoried inter cropping of turmeric with arecanut



Traditional method of terrace formation with local available stones



Silpaulin for water harvesting



Gabion retaining wall



Traditional stone bunding



Trench cum bund in aerable land



**ICAR- Indian Institute of Soil and Water Conservation
Research Centre, Udthagamandalam -643 004**