ISBN-978-81-92-4624-4-8

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

ICAR-Indian Institute of Soil & Water Conservation (IISWC)
218, Kaulagarh Road, Dehradun
(Uttarakhand 248 195)

ISBN-978-81-92-4624-4-8

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

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

Citation

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-ISBN-978-81-92-4624-4-8, 31p.

Guidance and Supervision by

Dr S. Bhaskar, ADG
(Agronomy, Agroforestry & Climate Change), #111, KAB-II, PUSA, NEW DELHI-110012

Compiled and Edited by

K. Kannan, H. C. Hombegowda, Gopal Kumar, Debashis Mandal, Pradeep Dogra, Rajesh Kaushal, and M. Madhu

Published by

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

FOREWORD

डा. टी. महापात्रा
सचिव एवं महानिदेशक
Dr T. Mahapatra
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय एवं फारमर्स वेल्फेयर
कृषि भवन, नई दिल्ली 110 001
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE & FARMERS WELFARE
KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629, 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

Soil and water are the most precious natural resources, the importance of which in human civilization needs no elaboration. The total available land area sets the limits within which the competing demands for agricultural, industrial, domestic and other purposes are to be met. This often results in diversion from one use to the other. Further, the available land is subjected to soil erosion of varying degrees and degradation problems of different magnitudes. Besides land, availability of water resources also plays a vital role in agricultural and industrial development and sustaining human life.

The risk of soil erosion in south Indian States is more serious. A lot of land can no longer sustain production mainly due to high intensity rainfall, deforestation and unscientific land use practices, thus leading to their abandonment.

Land degradation due to desertification, soil salinity/alkalinity, water logging, drought/flood, excessive soil erosion and intensive agricultural practices have resulted in the creation of vast stretches of wastelands covering about 3 million hectares (23% of TGA) in Tamil Nadu.

Realizing the need for the optimal utilization of land resources, the ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udagamandalam is working in collaboration with State Government organizations, NGOs and farmer interest groups for achieving Land Degradation Neutrality, cleaner production and doubling farmer's income through various scientific and technical interventions.

I hope, this document on "Soil erosion status, priority treatment areas and conservation measures for different districts of Tamil Nadu" prepared by ICAR-Indian Institute of Soil and Water Conservation, Dehradun will be helpful for land managers, State Government officials and policy makers to execute various cost effective land-based interventions more efficiently.

Dated the 23rd August, 2021
New Delhi

(T. Mahapatra)

MESSAGE

डा. एस. के. चौधरी
उप महानिदेशक (प्राकृतिक संसाधन प्रबंधन)
Dr S. K. Chaudhary
DEPUTY DIRECTOR GENERAL (NRM)

भारतीय कृषि अनुसंधान परिषद
कक्ष क. 101, कृषि अनुसंधान भवन–II, नई दिल्ली 110 012, भारत
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
Room No. 101, Krishi Anushandhan Bhavan-II, Pusa, New Delhi-110 012, India
Tel.: +91-11-25848364, 91-11-25848366
E-mail: ddg.nrm@icar.gov.in

I am happy to know that ICAR-Indian Institute of Soil & Water Conservation, Dehradun along with its Research Centre- Udhagamandalam has prepared a technical document on "Soil erosion status, priority treatment areas and conservation measures for different districts of Tamil Nadu" in compliance to the recommendations of the Regional Committee-VIII.

Soil erosion and water scarcity are two most important limitations restricting land productivity growth in Tamil Nadu. About 5.07 million ha of area is subjected to various degrees of soil erosion and land degradation. The per capita availability of water in Tamil Nadu is about 900 cubic meter water as compared to the national average of 2,200 cu m. Further, the prediction of increase in heat waves, droughts, rainfall events and a likelihood of more cyclonic activity for India, in the recently released IPCC's Sixth Assessment Report (AR6, 2021), warrants the need of innovative conservation measures and approach.

I am aware that the ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udhagamandalam, have developed various agronomic, vegetative and engineering measures, in a participatory approach, for arresting and averting land degradations and for scientific planning and management of the available resources in the Southern Plateau & Hill and West Coast plains & Hills agro ecological regions.

This document comprises district wise severity of erosion areas, soil erosion risk map of the state with different priority classes and their extent, critical problems and 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 efforts made by the authors for bringing out this document in the field of vital importance.

Dated the 23rd August, 2021
New Delhi

(S. K. Chaudhary)

PREFACE

The ICAR- Indian Institute of Soil and Water Conservation Research and Training Institute 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, Govt. of India. The Institute along with its eight Research Centres is specifically working in collaboration with other stakeholders for scientific planning, conservation and management of the natural resources particularly soil and water. The Research Centre –Udhagamandalam, strategically located in Niligiri district is mandated to develop soil water conservation (SWC) and land reclamation technologies for Southern Plateau & Hill and West Coast plains & Hills agro ecological regions including Tamil Nadu and Kerala besides imparting training to state government officials and developing model watersheds as a learning sites for further adoption and up scaling.

The background of development of this document on "Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of Tamil Nadu" 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 Tamil Nadu state. On the recommendations of the regional committee and subsequent suggestions of the ADG (Agronomy and Agroforestry) a team was constituted at the institute.

Tamil Nadu is one of the most water stressed states in India having per capita availability of 900 cubic meter water a year, compared to national average of 2,200 cubic meters. The prediction of more severe rains over southern India in the coming decades in recently released IPCC's Sixth Assessment Report (AR6, 2021), further underscores the requirement of refined and redesigned regional coping strategies.

The present document aimed identification of critical areas based on the permissible soil erosion rate and existing erosion rate at a given location in each districts of State. The document contains soil erosion status and erosion induced losses including production and monitory losses at national level as well as for Tamil Nadu. Conservation priority map and district specific agronomic, vegetative and engineering measures have also been included in order to accelerate the adoption and implementation of 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 Mr A. Asohan, Additional director of Agriculture (Research), Mr T. Aravali, Additional director of Agriculture, Directorate of Agriculture Tamil Nadu, Dr K. Subramaniyan, Professor and Head TNAU, E. Balasubramanian Assistant Engineer Agril. Engineering Department, The Nilgiris and Mrs Jiji Cyrac, librarian NBSSLUP, Nagpur.

(Authors)

CONTENTS

Chapter No.	Chapter	Page No.
1.0	**Introduction**	**1**
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 Loss & Monetary Loss	2
2.4	Nutrients Loss	2-3
2.5	Carbon Loss	3
2.6	Loss in Reservoir Capacity	3
3.0	**The Approach**	**4**
4.0	**Erosion Status, Production and Monitory loss and Conservation Planning for The State of Tamil Nadu**	**5-7**
4.1	About The State	5
4.2	Soil Erosion Rate	5
4.3	Production and Monetary Loss from Rainfed Crops Due to Soil Erosion	6
4.4	Area Under Risk	7
5.0	**Conclusion**	**26**
6.0	**References**	**27-28**
	Photographs	**29-31**

List of Tables

Table No.	Title	Page No.
4.1	District wise severity of erosion areas and critical problem with their possible solutions in Tamil Nadu	8-10
4.2	Soil and water conservation measures for different soil erosion priority classes	11-14
4.3	District wise agronomic and vegetative SWC measures in Tamil Nadu	15-21
4.4	Agroforestry solution for soil water conservation in Tamil Nadu	22-25

List Figures

Figure No.	Title	Page No.
2.1	Soil erosion and associated losses in India (GER- Gross erosion rate)	3
4.1	Estimated total production and monetary loss of rainfed crops due to soil erosion in Tamil Nadu state	6
4.2	Estimated productivity and monetary loss of rainfed crops due to soil erosion in Tamil Nadu state	7
4.3	Priority classes for erosion control in Tamil Nadu state	7

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, unscientific land use and land management practices. Erosion induced loss in crop production and farmers income, are of utmost cocern in India and globally. The total annual production loss was estimated as 13.4 million tonnes @ 15.7% (Sharda et al., 2010). As per valuation based on Government's minimum support prices during 2018-19, the loss was worth Rs 382.78 billion i.e. about 0.273% of Gross Domestic Product (GDP) of Rs 140.03 trillion. Further, by adopting a more pragmatic approach it was estimated that productivity loss at state level ranges 0.2-10.9 q ha^{-1} in rainfed crops of cereals, 0.1-6.3 q ha^{-1} in oilseeds, and 0.04-4.4 q ha^{-1} in pulses. India as a whole suffers a loss of 1.63 q ha^{-1} in productivity of rainfed crops (Sharda and Dogra, 2013). This loss was valued at Rs 4631 ha^{-1} considering the minimum support prices during 2018-19. The risk of soil erosion in south 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 22%, 9% and 5% of total geographical area (TGA) of Karnataka, Tamil Nadu and Kerala states, respectively, experiences moderate or moderate to severe soil erosion loss (Mandal et al., 2020). 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 lead 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 121.7 M ha area, which includes arable and non-arable lands, is subjected to various forms of land degradation (ICAR 2010), with maximum (82.6 M 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% from 4937 big dams and average life span reduction of dams by 25 yrs (Range 8-53 yrs).

2.3 Production Loss & Monetary Loss

Annual production and monetary losses due to water erosion were estimated by ICAR-IISWC, Dehradun by evolving and adopting a systematic approach which integrates data on erosion category-wise potentially eroded areas under major soil groups (alluvial, black or red) in each state with productivity loss factors (PLF) of 27 major rainfed crops, including cereals (8), oilseeds (10) and pulses (9), evolved through experimental studies in rainfed areas of different agro-climatic regions of the country. Following this approach, the total annual production loss was estimated as 13.4 million tonnes @ 15.7% (Sharda et al., 2010a). As per valuation based on Government's minimum support prices during 2018-19, this loss was Rs 382.78 billion. The GDP during 2018-19 was Rs. 140.03 trillion and the loss was about 0.273% of the GDP. The GDP Productivity loss at state level ranges 0.2-10.9 q ha^{-1} in rainfed crops of cereals, 0.1-6.3 q ha^{-1} in oilseeds, and 0.04-4.4 q ha^{-1} in pulses. National average loss in productivity of rainfed crops was estimated to be 1.63 q ha^{-1} (Sharda and Dogra, 2013). This loss was valued at Rs 4631 ha^{-1} considering the minimum support prices during 2018-19.

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

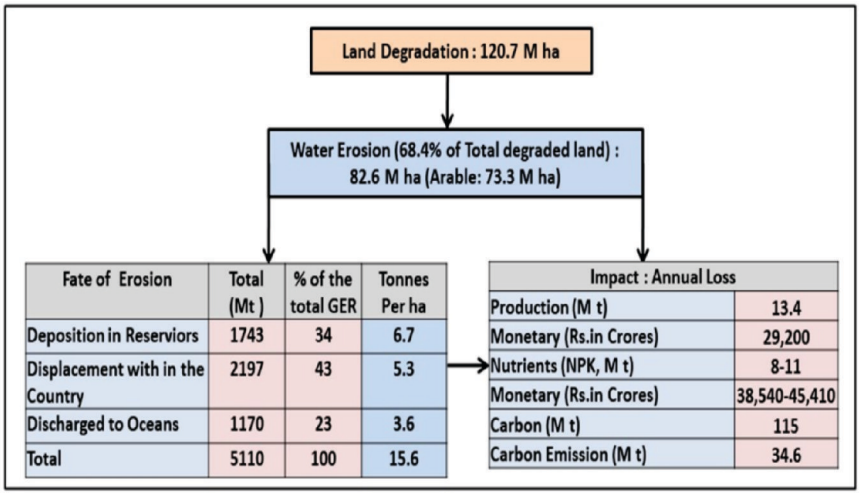
8.40 M t of nutrients in India (Sharda and Ojasvi, 2016) estimated total monetary loss of Rs 38,540 to 45,410 crores annually (2020 price). Further the estimated erosion linked loss of N, P, K, and S nutrient displacement as 4.41 to 9.61, 0.387 to 2.31, 4.43 and 1.27-1.65 million tonnes amounting to the corresponding monetary loss of Rs 13500- 29300, 1850-8320,17300 and 5890-7790 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 loss of 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 displacement due to water erosion in India is about 115 Mt yr^{-1} which consequently emits about 34.6 Mt of C to the atmosphere; erosion control can reduce C emission by 19.0 – 27.0 Mt yr^{-1} (Mandal et al., 2020).

2.6 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 % yr^{-1} 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 % yr^{-1}. 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. 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 Tamil Nadu. 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.

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 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 TAMIL NADU

4.1 About the State

It lies in southern most part of the Indian Peninsula. The climate of the state ranges from dry sub-humid to semi-arid. It has a coastline of about 910 km (600 mi) which is the country's third longest coastline. Apart from small parts of South Deccan Plateau, the state has been divided into two major physiographic regions, *viz*., Hill-Upland Range and Plain Lands. It is the only state in India which has both the Western Ghats and the Eastern Ghats within its boundary. The two Ghats meet at the Nilgiri Hills. Western Ghats dominate the entire western border with Kerala, effectively blocking much of the rain bearing clouds of southwest monsoon from entering the state. Eastern parts are fertile coastal plains and northern parts are a mix of hills and plains. The central and the south-central regions are arid plains and receive less rainfall than other regions. The mean annual rainfall of the state is about 945 mm, of which 48% is received through North- East monsoon and the remaining 32% through South- West monsoon. Since the state is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought.

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 1.11 M ha (8.56% of TGA) has severe (20-40 t ha^{-1} yr^{-1}) and very severe (>40 t ha^{-1} yr^{-1}) soil erosion rates whereas the low (<10 t ha^{-1} $yr^{-1)}$ and moderate (10-20 t ha^{-1} yr^{-1}) erosion classes cover 47.94% and 42.87% area, respectively (Fig. 4.1). Problem of soil erosion is more acute in hilly Western Ghats due to high rainfall induced excessive runoff conditions though it is also prevalent in Eastern Ghats and Nilgiri hills. In some lateritic landforms, deep rills and gullies are observed. The soil loss tolerance limit values vary between 5.0 and 12.5 t ha^{-1} yr^{-1}, indicating a medium degree of heterogeneity with respect to soil depth.

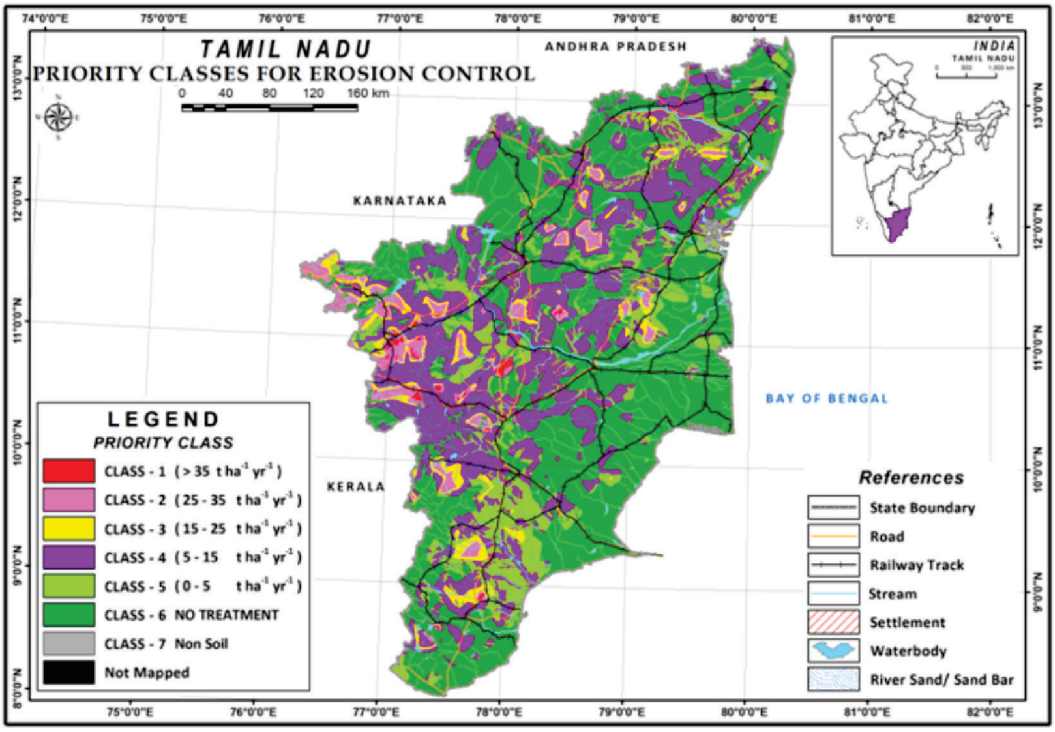


Fig. 4.1. Priority classes for erosion control in Tamil Nadu state

4.3 Production and Monetary Loss from Rainfed Crops Due to Soil Erosion

The production loss of cereal and millets, oilseed and pulse crops were estimated to be 16%, 26% and 19%, respectively whereas average loss considering cerels, oil seeds and pulses together was about 20%. Out of 0.3 million tonne in total production losses, 45.4% is due to losses in cereals and millets, 45.5% in oilseeds and 9.1% in pulses. In terms of monetary losses, 59.9% of the total loss of Rs 13036 million occurs in Tamil Nadu due to production losses in oilseeds, followed by 25.6% in cereals and millets and 14.5% in pulses (Fig. 4.2). The largest contribution is from groundnut (57%) followed by sorghum (8%), paddy (7%) and black gram (7%).

The productivity losses of cereal and millets, oilseed and pulse crops were estimated to be 185 kg ha^{-1}, 330 kg ha^{-1} and 57 kg ha^{-1}, respectively. The average productivity loss of all these crops together was 184 kg ha^{-1} (Sharda and Dogra, 2013), which in monetary terms was Rs 6887 ha^{-1} during 2018-19 (Fig 4.3). The Gross State Domestic Product (GSDP) of Tamil Nadu for 2018-19 at current prices was estimated to be Rs 15,97,814 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 0.08% of its GSDP during 2018-19.

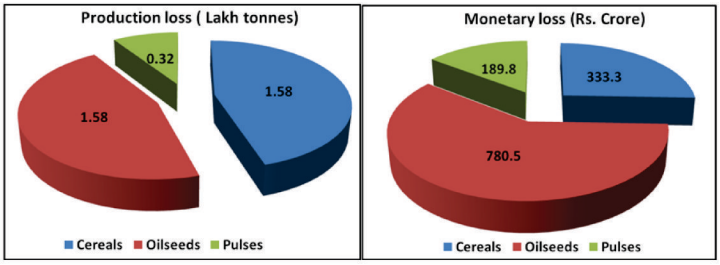


Fig. 4.2: Estimated total production and monetary loss of rainfed crops due to soil erosion in Tamil Nadu State

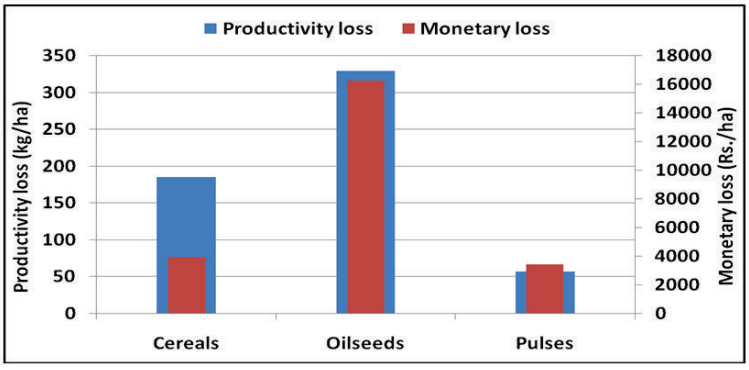


Fig. 4. 3: Estimated productivity (kg ha^{-1}) and monetary loss (Rs ha^{-1}) of rainfed crops due to soil erosion in Tamil Nadu State

4.4 Area Under Risk

The analysis revealed that 49.49% of state's TGA falls under no treatment category as the soil loss in these areas is within the permissible limits, while 50.31% 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 0.36, 3.96, 3.56, 28.97 and 13.46 %, respectively. As evident from the Table 4.1, though 47.94% area of the state falls under very low and low soil erosion categories, 21.77% area has high priority for conservation treatment with T-value upto 7.5 t ha^{-1} yr^{-1}. Similarly, though about 51.43% area has prevailing soil erosion rates of more than 10 t ha^{-1} yr^{-1}, about 42.43% still falls in priority classes 4 and 5. The analysis also revealed that only about 0.36% area falls under priority class 1 whereas by considering the soil loss tolerance limit, about 6.39% area was observed to be most vulnerable with T-value of 5.0 t ha^{-1} yr^{-1}. The spatial distribution of priority areas under different classes is presented in Fig. 4.1. 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 agroforestry measures.

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

S. No.	District	TGA (000 ha)	Area under risk (000, ha)	% area of the district	Special erosion problem	Conservation measures
Severity of risk- No risk						
1	Nagapattinam	256.9	0.0	0.0	Sea water Ingression and flood	Table 4.2-Sr No. 5.4, 6.1.7, 6.1.6 & 5.2 Table 4.4- Sr, No 14
2	Pudukkottai	464.4	0.0	0.0	Open Scrub and Gully erosion	Table 4.2-Sr No. 1.1, 1.4, 4.6, 6.2.4, 5.4, 3.1.1, 3.2.7, 6.1.7 Table 4.4- Sr, No 15
3	Thanjavur	341.1	0.0	0.0	Sea water Ingression	Table 4.2-Sr No. 5.4, 6.1.6, 6.1.7, 5.2 & 5.4 Table 4.4- Sr, No 14
4	Thiruvarur	227.4	0.0	0.0	Sea water Ingression and flood	Table 4.2-Sr No. 5.4, 6.1.6, 6.1.7, 5.2 & 5.4 Table 4.4- Sr, No 14
	Total	**1289.8**	**0.0**	**0.0**		
Severity of risk- A						
5	Ramanathapuram	410.4	0.01 (3:0.01)	0.002	Sea water Ingression	Table 4.2-Sr No. 1.4, 3.1.4, 4.6, 5.2, 6.1.7, Table 4.4- Sr, No 15
6	Tiruvallur	339.4	0.05 (1:0.01, 2:0.04)	0.01	Gully erosion	Table4. 2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 4.6, 5.2, 6.2.4 & 5.4 Table 4.4- Sr, No 12
7	Sivaganga	423.3	0.54 (3:0.04)	0.13	Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 1.4, 1.2, 4.6, 5.2 & 6.2.4 Table 4.4- Sr, No 15
8	Tiruchirappalli	450.9	5.00 (2:2.7, 3:2.3)	1.11	Scrub land, Loss of vegetation and agricultural land	Table 4.2-Sr No. 3.1.3, 4.6, 6.1.6, 6.1.1, 5.2, 6.1.7 & 5.4 Table 4.4- Sr, No 14 & 17
9	Kanyakumari	168.4	6.00 (2:0.6, 3:5.4)	3.56	Flood	Table 4.2-Sr No. 2.5, 2.7, 3.1.1, 5.4 & 6.1.7 Table 4.4- Sr, No 16
10	Krishnagiri	512.9	8.09 (2: 3.6, 3: 4.5)	1.58	Open Scrub	Table 4.2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 4.6, 5.2, 6.1.7, 6.2.4 & 5.4 Table 4.4- Sr, No 13

11	Cuddalore	370.3	8.77 (2:5.5, 3:5.5)	2.37	Mining and Sea water ingression	Table 4.2-Sr No. 2.7, 3.1.1, 3.1.3, 1.1, 3.2.3 & 6.1.7 Table 4.4- Sr, No 12
12	Madurai	371.0	13.57 (3:13.6)	3.66	Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 4.6, 6.1.7, 6.2.4, 3.2.5 & 5.2 Table 4.4- Sr, No 15
13	Kanchipuram	448.3	16.07 (2:4.7, 3:11.4)	3.59	Open scrub	Table 4.2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 4.6, 5.2, 6.1.7, 6.2.4 & 5.4 Table 4.4- Sr, No 12
14	Villupuram	719.4	18.60 (1:0.4, 2:11.0, 3:7.2)	2.59	Open scrub	Table 4.2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 6.1.7, 6.2.4 & 5.4 Table 4.4- Sr, No 12
15	Salem	523.7	18.98 (1:0.2, 2:13.3, 3:5.6)	3.62	Mining and Open Scrub	Table 4.2-Sr No. 3.1.1, 3.1.3, 3.2.3, 4.6, 5.2, 6.4, 5.4, 6.1.1, 6.1.7, 6.2.4 & 6.2.7 Table 4.4- Sr, No 13 &17
16	Karur	290.4	20.29 (1:11.6, 2:6.6, 3:2.1)	6.99	Open Scrub and Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 4.6, 6.1.7, 6.2.4, 3.2.5 & 5.2 Table 4.4- Sr, No 13
17	Vellore	607.5	20.57 (1:0.02, 2:10.3, 3:10.3)	3.39	Gully erosion	Table 4.2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 5.2, 6.4, 6.1.7, 6.2.4 & 5.4 Table 4.4- Sr, No 12 & 17
18	Tuticorin	474.5	26.32 (1:2.0, 2:5.5, 3:18.9)	5.55	Gully erosion	Table 4.2-Sr No. 1.9, 1.10, 3.1.4, 5.2, 5.4, 6.4 Table 4.4- Sr, No 15
19	Perambalur	175.6	26.81 (2:11.0, 3:15.8)	15.27	Mining	Table 4.2-Sr No. 1.9, 5.2, 5.4, 6.2.4, 6.1.7 & 4.6 Table 4.4- Sr, No 12
20	Erode	576.0	27.30 (1:0.4, 2:12.9, 3:14.0)	4.74	Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 1.2, 1.4, 1.7, 4.6, 5.2, 6.1.7 & 6.2.4 Table 4.4- Sr, No 11
21	Ariyalur	194.0	30.81 (2:11.1, 3:19.7)	15.88	Mining	Table 4.2-Sr No. 1.9, 5.2, 5.4, 65.2.4, 6.1.7 & 4.6 Table 4.4- Sr, No 12
22	Tiruvannamalai	618.8	33.67 (2:10.3, 3:23.4)	5.44	Open Scrub	Table 4.2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 6.1.7, 6.2.4 & 5.4 Table 4.4- Sr, No 12 & 17

23	Dharampuri	449.7	38.47 (1:0.4, 2:24.2, 3:14.0)	8.55	Open Scrub and Gully erosion	Table 4.2-Sr No. 1.1, 1.5, 1.7, 3.1.1, 6.1.7, 6.2.4 & 5.4 Table 4.4- Sr, No 13 & 17
24	Namakkal	342.0	41.74 (1: 2.2, 2:22.4, 3:17.1)	12.20	Open Scrub and Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 1.2, 1.4, 1.7, 4.6, 5.2, 6.1.7 & 6.2.4 Table 4.4- Sr, No 11
25	Virudhunagar	424.1	44.82 (2:9.0, 3:35.8)	10.57	Mining	Table 4.2-Sr No. 1.4, 3.1.7, 6.1.7, 5.2, 6.2.4 & 4.6 Table 4.4- Sr, No 15
26	Dindigul	603.6	46.60 (1: 5.0, 2:31.2, 3:10.4)	7.72	Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 4.6, 6.2.4, 5.2, 3.2.3 & 3.3.1 Table 4.4- Sr, No 11 &17
	Total	**9494.2**	**453.07**	**4.77**		
Severity of risk- B						
27	Tirunelveli	669.3	61.31 (1:0.12, 2:14.3, 3:46.9)	8.8	Wind erosion, gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 3.2.1, 5.2, 6.2.7, 6.2.4 & 4.6 Table 4.4- Sr, No 15
28	Teni	286.8	64.55 (2:27.6, 3:36.9)	22.2	Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 1.5, 1.7, 1.4, 1.2, 4.6, 5.2, 6.1.7 & 6.2.4 Table 4.4- Sr, No 15
	Total	**956.1**	**125.86**	**31.0**		
Severity of risk- C						
29	Nilgiri	256.5	133.05 (2:90.7,3: 42.3)	52.0	Accelerated soil erosion, Land slide, siltation in dams, Gully erosion	Table 4.2-Sr No. 3.3.2, 3.3.4, 2.5, 4.10, 1.7, 4.7, 6.2.11, 6.1.1, 6.2.8, 6.2.7, 6.2.12, 6.2.10 & 3.2.3 Table 4.4- Sr, No 17
30	Coimbatore	473.2	160.12 (1:9.2, 2:101.8, 3:49.2)	41.4	Open Scrub and Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 1.7, 6.1.1, 1.2, 4.6, 5.2, 6.2.4 & 6.1.7 Table 4.4- Sr, No 11
31	Tiruppur	518.7	161.16 (1:16.2, 2:89.0, 3:56.0)	27.3	Open Scrub and Gully erosion	Table 4.2-Sr No. 3.1.1, 3.1.3, 1.1, 1.7, 6.1.1, 1.2, 4.6, 5.2, 6.2.4 & 6.1.7 Table 4.4- Sr, No 11
	Total	**1248.4**	**454.3**	**36.4**		

Note: A= < 50,000 ha area is critical; B= between 50,000-1,00000 ha area is critical; C= > 1,00000 ha area is critical in a district. Critical area is the sum of area under priority class 1, 2 and 3. Data in Parentheses shows area under different priority class based on difference between potential erosion (Er) and soil loss tolerance limit (T) *i.e.* (E_r – TL); 1: (E_r – TL) >35 t ha^{-1} yr^{-1}, 2: (E_r – TL) in the range of 25-35 t ha^{-1} yr^{-1}, 3: (E_r – TL) in the range of 15-25 t ha^{-1} yr^{-1}. Table 4.2 represents different soil and water conservation measures for different land situations, Table 4.3 presents agronomic and vegetative measures and Table 4.4 represents district wise potential agroforestry systems (AFS).

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

S. No	Conservation Measures	Slope <10%		Slope-10-33%	
		Low priority class		High priority class	
		Arable land	Non arable land	Arable land	Non arable land
1.0	**Agronomic Measures (upto 6%, agronomic measures alone; >6% with other land management practices) refer Table 4.3 for details**				
	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:** Vetivera grass (*Vetiveria zizanioides)* ; Guatemala grass (*Tripsacum laxum*); Weeping love grass (*Eragrostis curvula);* Lemon grass (*Cymbopogon citratus);* Rosha/ palma rosa grass (*C. martinii);* Malabar (*C. flexuosus);* Hybrid Napier; Agave (*Agave americana & Agave sisalana);* Geranium (*Pelargonium graveolens);* Mulberry (*Morus alba); Pineapple (Ananas comosus)*				

3.0	**Mechanical/Engineering Measures**					
	3.1	**Bunding**				
	3.1.1	Contour/Field bunding/Trench-cum-bund	√	√	√	√
	3.1.2	Graded bunding (uniformly and variable graded)-Black soils	√			
	3.1.3	Stone bund (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			√	
	5.5	Pond lining	√	√	√	
	5.6	Roof top water harvesting	√		√	
	5.7	Diversion based water harvesting			√	√
		Special problem area				
6.0	**Mine spoil area/ Land Slide Prone Area**					
	6.1	**Vegetative**				
	6.1.1	Vegetative hedges		√		√
	6.1.2	Brushwood check dam				√
	6.1.3	Watling (live)				√
	6.1.4	Double-row Brushwood dam / Log wood brush filled check dam				√
	6.1.5	Grassed contour barrier		√		√
	6.1.6	Bamboo 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 for Tamilnadu referred in Table 2 is presented in Table 4.3

Note 2: For concept, design and estimates of soil and water conservation measures, kindly refer, Mishra, P. K., Juyal, 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 solutions for soil water conservation in Tamil Nadu kindly refer Table 4.4

Table 4.3: District wise area under various erosion risk and the possible agronomic and vegetative measures for Tamil Nadu District details:

District Details: A: Name of District, B: Total Geographical area, TGA (000, ha), C: Area under erosion risk ('000 ha), D: erosion risk area as a percentage of TGA, E: Special erosion problem

S. 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	**Name of District: Nagapattinam, TGA: 256.9, A(Er): 0.0, Er (%): 0.0, Sp.P: Sea water Ingression and flood**			
	Relay cropping of black gram in Rice fields Maize/pulses/vegetables (June-Sep.) – rice (Oct-Jan.) - pulses / cotton / Sesame / sunflower (Feb-May) Rice (June-Sep) - rice (Oct.-Jan.) - pulses/ sesame	Green mannuring with *Daincha* during summer in the rice field, Planting *Gliricidia sepium* in the field bunds	Planting perennial red gram on the bunds of rice fields Planting hybrid Napier grass around the pond	Flexi check dam for water harvesting and prevent sea water ingression Afforestration activities like raising coastal shelterbelt with *Casuriana* and Mangrove spp.
2	**Name of District : Pudukkottai, TGA: 464.4, A(Er): 0.0, Er (%): 0.0, Sp.P: Open Scrub and Gully erosion**			
	Crop rotation (cereal followed by black/ green gram), inter cropping millets with red gram and cowpea Rice (June-Sep) - rice (Oct.-Jan.) - pulses / sesame (Feb-May) Direct sown rice (Aug-Jan) - groundnut (Jan-Apr)		Vegetative Barriers with *Andropogan spp.* and *Cenhrus spp.* in waste land	Agave plantation along the gully Plantation of *Acacia holosericea, Anacardium* and *Eucalyptus spp.*
3	**Name of District: Thanjavur, TGA: 341.1, A(Er): 0.0, Er (%): 0.0, Sp.P: Sea water Ingression**			
	Relay cropping of black gram in Rice fields Maize/pulses/vegetables (June-Sep.) – rice (Oct.-Jan.) - pulses / cotton / sesame / sunflower (Feb.-May) Rice (June-Sep.) - rice (Oct.-Jan.) - pulses / sesame	Green manuring with *Dhaincha* during summer in the rice field Planting *Gliricidia sepium* in the field bund	Planting perennial red gram on the bunds of rice fields Planting hybrid Napier grass around the pond	Flexi check dam for water harvesting and prevent sea water ingression Afforestration activities like raising coastal shelterbelt with *Casuriana* and Mangrove spp.
4	**Name of District : Thiruvarur, TGA: 227.4, A(Er): 0.0, Er (%): 0.0, Sp.P: Sea water Ingression and flood**			
	Relay cropping of black gram in Rice fields Maize/pulses/vegetables (June-Sep.) – rice (Oct.-Jan.) - pulses / cotton / sesame / sunflower (Feb.-May) Rice (June-Sep.) - rice (Oct.-Jan.) - pulses / sesame	Green manuring with *Daincha* during summer in the rice field Planting *Gliricidia sepium* in the field bund	Planting perennial red gram on the bunds of rice fields Planting hybrid Napier grass around the pond	Flexi check dam for water harvesting and prevent sea water ingression Afforestration activities like raising coastal shelterbelt with *Casuriana* and Mangrove spp.
	TGA (000 ha):1289.8, Area under Severity of risk -No risk category :0.0, % of TGA under risk:0			

			Severity of risk- A	
5	**Name of District: Ramanathapuram, TGA: 410.4, A(Er): 0.01 (3:0.01), Er (%): 0.002, Sp.P: Sea water Ingression**			
	Upland rice/ millets /pulses Groundnut + redgram intercropping Cotton + cowpea intercropping	Sunhemp cultivation once in three years	Alley cropping cotton, pulses and millets with *Leucaena leucocephala* alley Medicinal crops like Senna, *Vinca rosea*	*Casuriana* plantation along the coast Agave plantation along the gully
6	**Name of District: Tiruvallur, TGA: 339.4, A(Er): 0.05, Er (%): (1:0.01, 2:0.04), Sp.P: 0.01 Gully erosion**			
	Tapioca + ground nut Rainfed rice - pulses Pulses –ground nut Contour cultivation agri-horti (Mango) Tamarind, coconut with ground nut, and horse gram	Cover crop with horse gram, cover cropping with horse gram, Plastic mulching for vegetables cultivation	Aswagandha – lablab Hybrid Napier fodder grass and guinea grass in coconut plantation	Grassed water ways with Bamboo and Lemon grass
7	**Name of District: Sivaganga, TGA: 423.3, A(Er): 0.54, Er (%): (3:0.04), E : 0.13, Sp.P: Gully erosion**			
	Agri-horti with Guava Intercropping ground nut + pulses Minot millets + red gram /cowpea Crop rotation Ground nut -sesame Agroforestry (Eucalyptus, *Acacia auriculiformis*, *A.* holocericea & *Casuarina*) Contour cultivation	Sunhemp cultivation once in three years	Vegetative Barriers with *Andropogan spp.* and *Cenhrus spp.* in waste land	Agave plantation along the gully
8	**Name of District: Tiruchirappalli, TGA: 450.9, A(Er): 5.00(2:2.7, 3:2.3), Er (%): 1.11, Sp.P: Scrub land, Loss of vegetation and agril. land**			
	Rice-pulses/sesame and maize/pulses - rice in irrigated area Ground nut + red gram in rainfed areas	Green manuring with *Daincha*	Land levelling, contour rubble bunds with vegetative hedges in the Pachamalai hill area Medicinal Coleus / *Vincia rosea* / Senna during drought	Afforestration activities like teak plantation in the canal side
9	**Name of District: Kanyakumari, TGA:168.4, A(Er): 6.00 (2:0.6, 3:5.4), Er (%): 3.56, Sp.P: Flood**			
	Rice (June-Oct.) - rice (Oct.-Feb.) – pulses Banana - ratoon banana (April - Jan.) - (2 years) Maize/ cluster bean / lab lab / bhendi (Oct.-Feb) followed by pulses Tapioca + pulses Caster	Green manuring with *Daincha*	Cultivation of hybrid Napier under plantation crops	

10	**Name of District: Krishnagiri, TGA: 512.9, A(Er): 8.09(2: 3.6, 3: 4.5), Er (%): 1.58, Sp.P: Open Scrub**			
	Tapioca Ragi + lablab Ragi/ little millet- horse gram Rainfed tomato - horse gram Agro forestry with Melia and teak in irrigated area, Agri - horti (Mango, tamarind, coconut with ground nut, and horse gram Contour cultivation	Plastic mulching Cover crop with horse gram	Contour rubble bunds with vegetative hedges (Napier grass) in the hilly area	Afforestration in open scrub with *Acacia, Albizzia Bauhinia, Tectona and Anogeissus* Boundary plantation in the foot hills and trenching in plantation crops in hills
11	**Name of District: Cuddalore, TGA: 370.3, A(Er): 8.77(2:5.5, 3:5.5),Er (%): 2.37, Sp.P: Mining and Sea water ingression**			
	Rice- pulses/ sesame Maize- pulses Maize-cluster bean / lablab / *bendi* fallowed by rice Contour cultivation in rainfed red soil area of Panruti, Virudhachalam area	Green Manuring with *Daincha*	Vettiver grass plantation for medicinal use	Agro-forestry with *Cashew* and *Casuarina* Trenching in Cashew plantation
12	**Name of District: Madurai, TGA: 371.0, A(Er): 13.57 (3:13.6), Er (%): 3.66, Sp.P: Gully erosion**			
	Rice – cotton/ green manure/senna Maize + cluster bean/ lablab Cotton + pulses Pearl millet+ cluster bean contour cultivation Agro-horti (coconut, mango, sapota, guava and moringa)	Green manuring with *Daincha* in irrigated area Horse gram in rainfed area	Medicinal crop Senna and stevia in coconut plantation	Agave plantation along the gully Grassed water ways with Bamboo and Lemon grass in hilly areas
13	**Name of District: Kanchipuram, TGA: 448.3, A(Er): 16.07 (2:4.7, 3:11.4), Er (%): 3.59, Sp.P: Open scrub**			
	Tapioca + ground nut Rainfed rice - pulses Pulsues –groundnut Contour cultivation agri-horti (mango) Tamarind, coconut with ground nut, and horse gram	Cover crop with horse gram, cover cropping with horse gram Plastic mulching for vegetables cultivation	Aswagandha – Lablab Hybrid Napier fodder grass Guinea grass in coconut plantation	Grassed water ways with Bamboo and Lemon grass

14	**Name of District: Villupuram, TGA: 719.4, A(Er): 18.60(1:0.4, 2:11.0, 3:7.2), Er (%):2.59, Sp.P: Open scrub**			
	Tapioca + ground nut Rainfed rice-pulses Pulsues –groundnut Contour cultivation agri-horti (mango) Tamarind, coconut with ground nut and horse gram	Cover crop with horse gram Plastic mulching for vegetables cultivation	Aswagandha – Lablab Hybrid Napier fodder grass Guinea grass in coconut plantation	Grassed water ways with Bamboo and Lemon grass
15	**Name of District: Salem, TGA: 523.7, A(Er): 18.98(1:0.2, 2:13.3, 3:5.6), Er (%): 3.62, Sp.P: Mining and Open Scrub**			
	Tapioca Ground nut + castor/pulses- horse gram Sorghum + pulses Rainfed tomato – horse gram Mixed plantation coffee + pepper + arecanut + fruit trees	Cover crop with horse gram, cover cropping with horse gram Plastic mulching for vegetables cultivation	Stevia/ fodder grasses like hybrid Napier in coconut garden Contour rubble bunding vegetative barrier and trenching in plantation crops in Yercaud hills	Agro-forestry in the mine spoil area with Acacia Contour bund in the sloppy red soil area
16	**Name of District: Karur, TGA: 290.4, A(Er): 20.29(1:11.6, 2:6.6, 3:2.1), Er (%): 6.99, Sp.P: Open Scrub and Gully erosion**			
	Rice – rice- pulses and Rice – cotton/ green manure/ senna in irrigated area Maize/millets- pulses Groundnut + pulses / castor Annual moringa Groundnut + red gram Agro-horti (coconut, mango, sapota, guava and moringa)	Green Manuring with *Daincha* in irrigated area Horse gram in rainfed area	Medicinal crop senna Stevia in coconut plantation	Agave plantation along the gully
17	**Name of District: Vellore, TGA: 607.5, A(Er): 20.57(1:0.02, 2:10.3, 3:10.3), Er (%): 3.39, Sp.P: Gully erosion**			
	Pearl millet / sorghum – ground nut Seasame - ground nut Maize / vegetables – marigold Rice- pulse/ sesame Agri-horti (mango, tamarind, coconut with ground nut, and horse gram Agro forestry with Melia and teak in irrigated area Contour cultivation	Cover crop with horse gram Plastic mulching for vegetable crops	Aswagandha - pulses	Grassed water ways with Bamboo and Lemon grass
18	**Name of District: Tuticorin, TGA: 474.5, A(Er): 26.32(1:2.0, 2:5.5, 3:18.9), Er (%): 5.55, Sp.P: Gully erosion**			
	Maize - chilly Maize/cluster bean Chilly / groundnut – cotton Cotton + black gram / chilly Sunflower / pearl millet/ cluster bean Neem, Casuarina and Eucalyptus based agro-forestry	Cover crop with sunhemp	Medicinal plants like Senna and *Vinca rosea*	Agave plantation along the gully Neem plantation along gullies Casuarina plantation along the coastal region
19	**Name of District: Perambalur, TGA: 175.6, A(Er): 26.81(2:11.0, 3:15.8), Er (%): 15.27, Sp.P: Mining**			
	Rice – ground nut / sesame Sesame – cotton + coriander Sesame – horse gram Coriander / ground nut Agro-forestry with Eucalyptus, *Casuarina* and *Melia dubea*	Horse gram as cover crop during October - Jan	Senna and *Vinca rosea* medicinal crop in marginal land Guinea and hybrid Napier grass in coconut plantation	Afforestration with *Prosopsis* and Neem

20	**Name of District: Erode, TGA: 576.0, A(Er): 27.30(1:0.4, 2:12.9, 3:14.0), Er (%): 4.74, Sp.P: Gully erosion**			
	Ground nut+ red gram / cowpea / caster Maize – pulses Fodder sorghum – horse gram Contour cultivation Agro-forestry (Coconut, *Melia dubea,* Eucalyptus) Agri-horti (Mango)	Horse gram as cover crop during October - Jan	Medicinal coleus- maize rotation Senna/ *Vinca rosea* during rabi cropping Guinea and hybrid Napier in coconut plantation	Agave and Neem plantation along the gully
21	**Name of District: Ariyalur, TGA: 194.0, A(Er): 30.81(2:11.1, 3:19.7), A(Er): 15.88, Sp.P: Mining**			
	Rice – ground nut/ sesame Sesame – cotton + coriander Sesame – horse gram Coriander / ground nut Agro-forestry with *Eucalyptus, casuarina* and *Melia dubea*	Horse gram as cover crop during October - Jan	Senna/ *Vinca rosea* during rabi cropping Guinea and hybrid Napier in coconut plantation	Afforestration with *Prosopsis* and Neem
22	**Name of District: Tiruvannamalai, TGA: 618.8, A(Er): 33.67(2:10.3, 3:23.4), A(Er): 5.44, Sp.P: Open Scrub**			
	Rice/maize – pulses/ sesame Rice – ground nut / seasame Peral millet / sorghum – ground nut Sesame - ground nut Maize / vegetables – marigold Sunflower + ragi/pulses Agri-horti (mango, tamarind, coconut with ground nut, and horse gram	Cover crop with horse gram, Plastic mulching for vegetable crops	*Aloe vera* in block soil areas	Grassed water ways with Bamboo and Lemon grass
23	**Name of District: Dharampuri, TGA: 449.7, A(Er): 38.47(1:0.4, 2:24.2, 3:14.0), A(Er): 8.55, Sp.P: Open Scrub and Gully erosion**			
	Tapioca Ragi + lablab Ragi/ little millet- horse gram Rainfed tomato - horse gram Agro forestry with Melia and teak in irrigated area, Agri-horti (mango, tamarind, coconut with ground nut, and horse gram Contour cultivation	Plastic mulching for vegetable crops Cover crop with horse gram	Contour rubble bunds with vegetative hedges (Napier grass) in the hilly area	Afforestration in open scrub with *Acacia, Albizzia Bauhinia, Tectona* and *Anogeissus* Boundary plantation in the foot hills and trenching in plantation crops in hills Agave plantation along the gully
24	**Name of District: Namakkal, TGA: 342.0, A(Er): 41.74(1: 2.2, 2:22.4, 3:17.1), A(Er): 12.20, Sp.P: Open Scrub and Gully erosion**			
	Rice – green manure/ ground nut Ground nut/ cotton- pulses Ground nut – maize Ground nut + caster/pulses- horse gram Tapioca Millets + red gram Contour cultivation Agro-forestry (coconut, *Melia dubea* and *Eucalyptus*), Agri-horti (Mango + ground nut)	Horse gram cover crop during October- Dec.	Medicinal coleus – maize Contour rubble bunds with vegetative hedges in Kolli malai hilly area	Agave plantation along the gully Grassed water ways with Bamboo and Lemon grass in the hilly areas

25	**Name of District: Virudhunagar, TGA: 424.1, A(Er): 44.82 (2:9.0, 3:35.8), A(Er): 10.57, Sp.P: Mining**			
	Upland rice/ millets/pulses Ground nut + red gram intercropping Cotton + cowpea/black gram and pearl millet + cluster bean intercropping	Sunhemp cultivation once in three years	Alley cropping cotton, pulses and millets with *Leucaena leucocephala* and Sesbania spp. alley Medicinal crops like Senna and *Vinca rosea*	Planting *Prosopsis* species in mine spoiled areas Agave plantation along the gully
26	**Name of District: Dindigul, TGA: 603.6, A(Er): 46.60(1: 5.0, 2:31.2, 3:10.4), A(Er): 7.72, Sp.P: Gully erosion**			
	Rice/pulses Maize-pulses/sesame Cotton – coleus Ground nut + pulses / maize Caster+ pulses Agro-horti (coconut, mango, sapota, guava and moringa)	Green manuring with *Daincha* in irrigated area Horse gram in rainfed area	Medicinal coleous in crop rotation Stevia in coconut plantation	Agave plantation along the gully Grassed water ways with Bamboo and Lemon grass in hilly areas
	TGA (000 ha): 9494.2, Area under Severity of risk A: 453.07, % of TGA under risk: 4.77			
	Severity of risk- B			
27	**Name of District: Tirunelveli, TGA: 669.3, A(Er): 61.31(1:0.12, 2:14.3, 3:46.9), A(Er): 8.8, Sp.P: Wind erosion, gully erosion**			
	Cotton + black gram / chillies Sorghum / ground nut/ sesame in red soil Rice – pulses, ground nut – cotton in irrigated area Contour farming in rainfed area Agro-forestry with *Melia* in foot hills	Green manuring with *Daincha* in rice cropping system	Napier fodder grass Medicinal coleus with crop rotation	Sand dune stabilization with *A cacia planifolia* in arid region Grassed water ways with Lemon grass and Bamboo in hilly areas
28	**Name of District: Teni, TGA: 286.8, A(Er): 64.55(2:27.6, 3:36.9), A(Er): 22.2, Sp.P: Gully erosion**			
	Rice – rice - green manure in command area Cotton – millets / vegetables / ground nut Annual moringa Millets/ ground nut / pulses Castor + pulses Agro-forestry (coconut, *Melia dubea)* Agri-horti (Mango)	Horse gram cover crop during October- Dec.	Medicinal coleus – cotton Gloriosa (2-year rotation) / medicinal coleus Contour rubble bunds with vegetative hedges in Kolli malai hilly area	Grassed water ways with Bamboo and Lemon grass Agave plantation along the gully
	TGA (000 ha): 956.1, Area under Severity of risk A: 125.86, % of TGA under risk: 31.0			
	Severity of risk- C			
29	**Name of District: Nilgiri, TGA: 256.5, A(Er): 133.05(2:90.7,3: 42.3), A(Er): 52.0, Sp.P: Accelerated soil erosion, Land slide, siltation in dams, Gully erosion**			
	Vegetables (potato/ carrot/ cabbage – beans rotation in terraces Vegetable – cover crop rotation in terraces	Cover crop (buck wheat/mustard/fodder oats/lupin) in winter fallow Mulching in tea garden with fern and *Gautemala* grass	Mixed vegetative barrier (Pineapple + grass) in plantation crop Puertorican terrace formation with grasses like hybrid Napier, and *Gautemala*, and medicinal crop like geranium	Grass with Jute geo textiles for slope stabilization Grassed waterways and live check dam

			Bench terrace stabilization with hybrid Napier grass, tea, perennial beans and medicinal crops like thyme and geranium Grass vegetative barrier and intercropping of beans in young tea plantation	Mixed plantation coffee +pepper+ arecanut+ shade trees like Jackfruit, Silver oak and *Erythrina.* Tea with silver oak + orange
30	**Name of District: Coimbatore, TGA: 473.2, A(Er): 160.12(1:9.2, 2:101.8, 3:49.2), A(Er): 41.4, Sp.P: Open Scrub and Gully erosion**			
	Cotton - sorghum Pearl millet - maize Ragi - pulse Caster/sorghum + pulse Contour cultivation, compartmental bund in black soil Agro-forestry (coconut, *Melia dubea* and Eucalyptus) Agri-horti (Mango)	Horse gram as cover crop during October - Jan	Medicinal coleus- maize rotation Guinea and hybrid Napier in coconut plantation	Traditional Silvi Pasture (*A cacia leucophloea* + *Cenchrus ciliaris*)
31	**Name of District: Tiruppur, TGA: 518.7, A(Er): 161.16 (1:16.2, 2:89.0, 3:56.0), A(Er): 27.3, Sp.P: Open Scrub and Gully erosion**			
	Cotton - sorghum Pearl millet - maize Ragi - pulse Caster/sorghum + pulse Contour cultivation, compartmental bund in black soil Agro-forestry (coconut, Melia dubea, Eucalyptus) Agri-horti (Mango)	Horse gram as cover crop during October - Jan	Medicinal coleus- maize rotation Guinea and hybrid Napier in coconut plantation	Agave plantation along the gully Traditional Silvi Pasture (*A cacia leucophloea* + *Cenchrus ciliaris*)
TGA (000 ha): 1248.4, Area under Severity of risk A: 454.3, % of TGA under risk: 36.4				

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. Severity Risk A= < 50,000 ha area is critical; severity Risk B= between 50,000-100,000 ha area is critical; Severity Risk C= > 100,000 ha area is critical in a district. Critical area is the sum of area under priority class 1, 2 and 3. Data in Parentheses shows area under different priority class based on difference between potential erosion (Er) and soil loss tolerance limit (T) i.e. (E_r – TL); 1: (E_r – TL) >35 t ha^{-1} yr^{-1}, 2: (E_r – TL) in the range of 25-35 t ha^{-1} yr^{-1}, 3: (E_r – TL) in the range of 15-25 t ha^{-1} yr^{-1}. Table 4.2 represents different soil and water conservation measures for different land situations, Table 4.3 represents details of agronomical and vegetative measures and Table 4.4 represents district wise potential agroforestry systems (AFS)

Table 4.4: Agroforestry solutions for soil water conservation in Tamil Nadu

S. N.	Agroclimatic Zone	Districts	AFS for arable lands	AFS for non-arable lands	Special problem area (Mining/gully/open scrub)
1	Western Zone	Coimbatore, Erode, Tiruppur, Part of Dindigul District, Karur and Theni district	**Silvi pasture** a) Traditional silvi-pasture system (*Korangadu*). In semi-arid region *Acacia leucophloea* with grass species like *Cenchrus ciliaris*. Pulses like *Macrotyloma uniflorum, Phaseolus trilobus* once sowing horsegram. Often live fenced with *Commiphora caudata*	a) Silvipasture system	a) Contour bund, Loose boulder check dam (LBCD), Gabion Check Dam (GCD), Gabion stream bank protection wall for gully control.
			Agrisilviculture b) Block plantation of *Melia dubia, Ceiba pentandra* and border/bund plantation of *Melia dubia, Tamarindus indica, Azadirachta indica, Ailanthus excelsa* with groundnut, turmeric, tapioca, onion, cotton, red gram, green gram and maize.		
			Agri-horticulture/pasture c) Coconut with groundnut/green gram/cowpea, turmeric for initial three years. Coconut with hybrid Napier/guinea grass after seven years of coconut plantation. d) Block plantation/bund plantation of annual moringa (*Morinda tinctoria*) and inter cropping of pulses and oil seeds. e) Fruit trees like mango, guava and aonla with oil seeds and pulses. *f*) Melia dubia intercropped with curry leaf (*Murraya koenigii*)		

2	North Eastern zone	Chengalpattu, Vellore, Thiruvannamalai Cuddalore, Villupuram, Ariyalur and Perambalur district	**Agri-silviculture**– a) Border plantation of teak (*Tectona grandis*) with sugarcane, maize, tapioca and groundnut in irrigated area. *b) Casurania* sp with groundnut/pulses and water melon in coastal belt	a)Teak (*Tectona grandis),* Jamum (*Syzygium cumini0*, Sisso (*Dalbergia sissoo*), Arjun (*Termnalia arjuna)* and Bamboo (*Bambusa arundinacea)* along the canals and rivers. b) Casuarina as shelterbelts along the coast line and inland to protect vast cultivated areas during inclement weather and cyclones.	LBCD and GCD for gully control, Reforestation with staggered trenches in open scrub. Afforestation/Reforetation with trenches in mine spoils area.
			Agri-horticultre– c) Cashew (*Anacardium occidental*) with green gram/black gram and groundnut. d) Border plantation of *Artocarpus heterophyllus* with groundnut and pulses		
3	North Western zone	Dharmapuri, Krishnagiri, Salem and Namakka	**Agri-horticulture**– a) Mango with sorghum, finger millet and ground nut in irrigated area. Tamarind with horse gram, groundnut and green gram in rainfed area	a) Teak (*Tectona grandis),* Jamum (*Syzygium cumini0*, Sisso (*Dalbergia sissoo*), Arjun (*Termnalia arjuna)* and Bamboo (*Bambusa arundinacea)* recommended along the canals and rivers	Staggered trenching and re-forestation in open scrub, LBCD and GCD for gully control
			Agri-silviculture- b) Eucalyptus with sorghum, border plantation of silver oak, *Hardwickia binata, Albizia amra, Pongamia pinnata, Azadirachta indica, Artocarpus heterophyllus*, *Tectona grandis* with *Dolichos lablab,* ragi, tomato and brinjal		
			Horti-silviculture- *c) Melia dubia* in Coconut garden		

4	Cauvery Delta zone	Thanjavur, Nagapattinum, part of Trichy and part of Pudukkottai district, part of South Vellore district	**Agri-silviculture-** a) Bund plantation of *Acacia nilotica* and *Thespesia populnea* and *Casuarinas* with paddy. *Hardwickia binnata* as block plantation or in scattered manner with sorghum, ragi and finger millet	a) Teak (*Tectona grandis),* Jamum (*Syzygium cumini0,* Sisso (*Dalbergia sissoo*), Arjun (*Termnalia arjuna)* and Bamboo (*Bambusa arundinacea)* recommended along the canals and rivers.	Shelter belts with Casuarina and mangroves against cyclones. Flexible check dam for controlling sea water intrusion. Afforestation with *A. planiformis, Prosopis*, *Azadirachta indica* in alkali soils, *Casurina. Pongamia*, silk cotton, tamarind plantation in saline soils
5	Southern zone	Pudukkottai, Madurai, part of Dindigul, Virudhunagar, Ramanathapuram, Tutticorin, Thirunelvel, and Sivaganga	**Agri-silviculture-** a) Éucalyptus sp. with millets in Pudukottai and Sivagangai district. *Acacia auricliformis, A. holoceratia* in Pudukottai district. Intercropping of cotton and chillies with *Ceiba pentandra* and *Sesbania grandiflora* trees. Border plantation of *Pithecellobium dulce / Azadirachta indica* / Tamarind in cotton and millets in black cotton region. Border plantation of *Tectona grandis, Dalbergia sissoo* inthe foot hill of western Ghat. Bund plantation and scattered plantation of Palmyra tree with agricultural crop in Virudhunagar, Thirunelveli, Tutticorin and Ramanathapuram district.	a) Block plantation of *Prosopis julifora* in Ramanathapuram district. b) Plantation of Acacia planiformis and Palmyra tree (*Borassus flabellifer*) on sandy soils of arid region of Thirunelveli district for stabilization of sand dunes.	LBCD and GCD for gully control, Afforestation with *A. planiformis, Prosopis*, *Azadirachta indica* in alkali soils, *Casurina. Pongamia*, silk cotton, tamarind plantation in saline soils Afforestation in mine spoil area.
			Agri-horticulture- b) Inter cropping fruit trees like mango, sapota, *Morinda tinctoria* and guava with pulses and oil seeds in Didndugul and guava with cotton/millets in Virudhunagar district. Border plantation of Jack fruit with pulses and oilseeds in Pudukottai district		
			Silvipasture- c) Silvipasture consists of *Leucaena leucocephala, Acacia planifrons* and *Prosopis juliflora*	c) Planting of *A. auriculiformis* and *A. holoceratia* as block plantation in saline soils	

6	High rainfall zone	Kanyakumari district	**Home garden–** **a)** Mixed cropping of Coconut, Jack fruit, rubber tree, Jamun, pepper, Arecanut, banana and pineapple		
7	Hilly zone	Kollimalai, Shervroys of Salem district, Elagiri and Javadi of Vellore district, Patchamalai of Trichy district, Palani of Dindigul district and Nilgiri district	**Agrisilviculture–** a) Border plantation of Jack furit, *Areca catechu*, Jamun, Mango with field crops. Silver oak inter cropped with ragi, Dolichous lablab and tapioca	a) Silver oak (*Grevillea robusta*), *Erithrina indica,* Jack fruit recommended as shade tree for coffee and tea plantation. Multi storey plantation involving tea, coffee, clove, nutmeg, pepper and areca nut in Kothagiri region of Nilgiri district and mixed plantation of guava, mango, Jack fruit, pepper, coconut and coffee are the viable option in Yercaud hills and Vathalalmalai hills	Brush wood check dam, grass planting on the bunds for gully control, Jute geo textiles for slope stabilization, contour staggered trenches in sloppy land, Gabion drop structures and gabion stream bank protection wall for gully control.

5.0 CONCLUSION

About 50.31% area of Tamil Nadu requires various degrees of soil erosion management out of which about 22% area has high priority for conservation treatment with T-value upto 7.5 t ha^{-1} yr^{-1}. A total area under three priority classes (Class 1, 2 and 3) is 1033.3 thousand hectares out of which about 47.5 thousand hectares are under very high priority category (Priority class 1). Tiruppur (161.2 thousand hectares), Coimbatore (160.1 thousand hectares) and Nilgiri (133.05 thousand hectares) districts are having the highest area needed priority treatment of soil and water conservation. Problem of soil erosion is more acute in hilly Western Ghats due to high rainfall induced excessive runoff conditions though it is also prevalent in Eastern Ghats and Nilgiri hills. In some lateritic landforms, deep rills and gullies are observed. Other special problems include open scrub, gully erosion, mining, sea water ingress, floods, land slides which warrants 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 aim 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-6-1247-2015

Down to Earth, 2016. Deluge despite deficit

(https://www.downtoearth.org.in/archives?get_year=2016&lang=english)

https://kvk.icar.gov.in/Contigencyplan/Bangalore%20Ruralaa9ac6f8-8669-4334-9c7e-42c240301a88.pdf

https://pmksy.gov.in/mis/Uploads/2016/20161224053438358-1.pdf

https://cdn.s3waas.gov.in/s35751ec3e9a4feab575962e78e006250d/uploads/2019/11/2019112613.pdf

https://cdn.s3waas.gov.in/s35751ec3e9a4feab575962e78e006250d/uploads/2019/11/2019112613.pd

https://krishi.icar.gov.in/jspui/bitstream/123456789/30676/1/KAR11

https://krishi.icar.gov.in/jspui/bitstream/123456789/30676/1/KAR11

http://cwc.gov.in/sites/default/files/reference-manual-climate-change-adaptation-guide-lines.pdf)

https://pmksy.gov.in/mis/Uploads/2016/20161220120144836-1.pdf.

http://www.icarkvkmandya.com/districtProfile.html.

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., & 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.)

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 (Forthcoming)

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. http://nicra-icar.in/nicrarevised/images/statewiseplans/Contingency%20crop%20bk_27-7-2012%20Full%20Book%20Proof%2028-7-2012-High-1.pdf

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. DOI 10.1007/s40003- 013-0087-1.

Sharda, V.N. and Mandal, D. 2018. Prioritization and Field Validation of Erosion risk areas 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 accessed on 18th May, 2021)

Vegetative barrier with pineapple

Vegetative barrier with fodder grass

Contour farming

Intercropping legumes with millets

Buckwheat: Cover crop for hilly regions

Papaya with plastic mulch and green manure

Earthen bund for *insitu* moisture conservation

Stone bund in tea plantation

Bench terraces for higher slopes

Trenching with mulch for plantation crops

Alternate land use: Agri horticulture

Alternate land use: Silvi-Agriculture

Farm pond for supplementary irrigation

Loose boulder check dam for gully erosion control

Gabion Check dam for gully erosion control

Check dam for water harvesting

Percolation pond

Flexi check dam

ICAR-Indian Institute of Soil & Water Conservation (IISWC)

218, Kaulagarh Road, Dehradun (Uttarakhand 248 195)