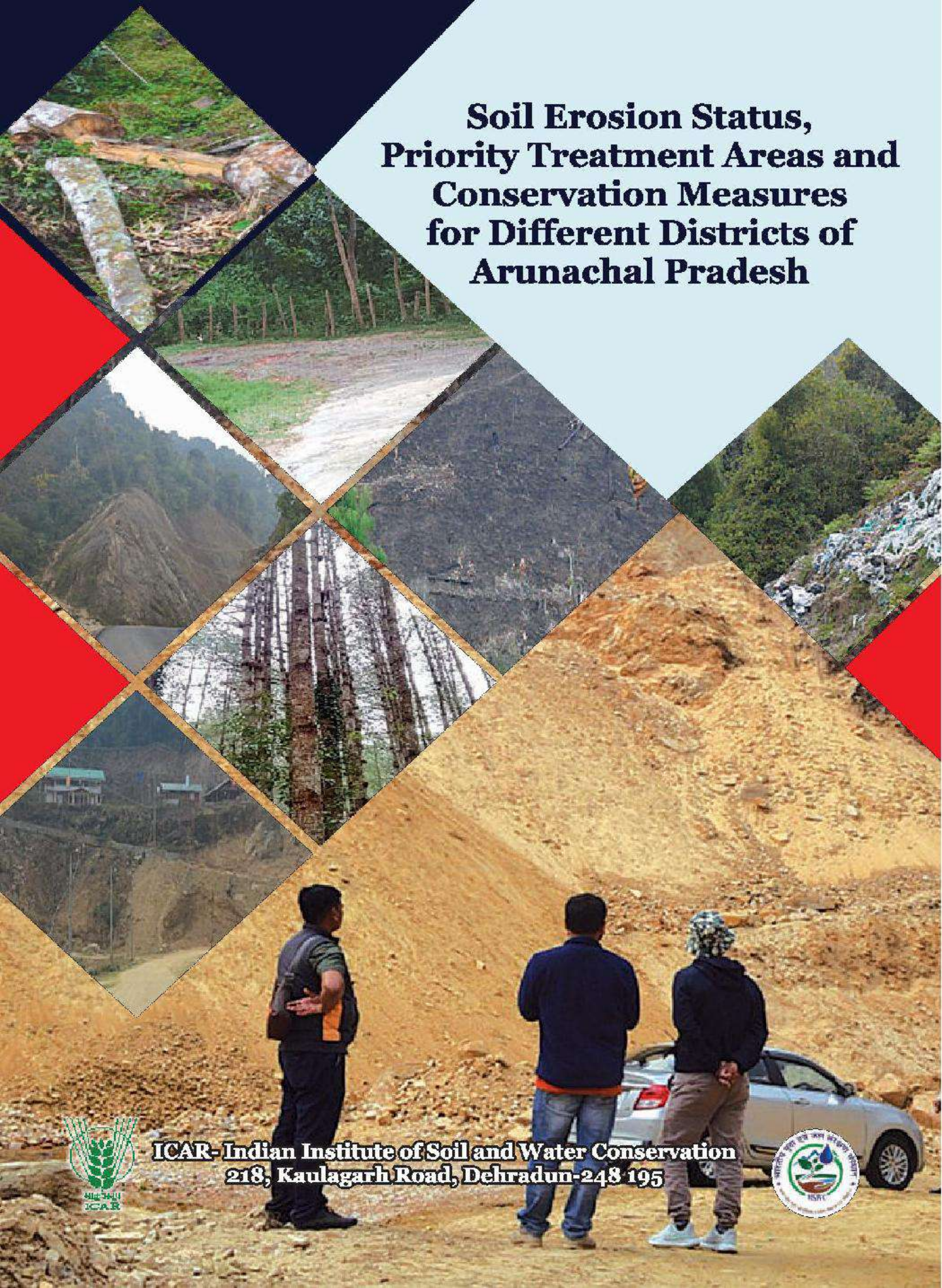
Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of Arunachal Pradesh



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Citation

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उप महानिदेशक (प्राकृतिक संसाधन प्रबंधन)
Dr. Suresh Kumar Chaudhari
Deputy Director General (Natural Resources Management)

28.08.2023

Message

Arunachal Pradesh is the largest of the Seven Sister States of Northeast India by area facing water induced erosion resulting in loss of top surface fertile soil, creation of rills and decline in crop productivity. According to data on soil loss / erosion tolerance limits, the soil loss tolerance limit (SLTL) in Arunachal Pradesh ranges between 7.5 and 10.0 t ha^{-1} yr^{-1} for different erosion risk groups. It is, therefore, crucial to address these challenges strategically and promptly to prevent soil erosion and conseve biodiversity.

I am happy to know that ICAR-Indian Institute of Soil & Water Conservation (IISWC), Dehradun has prepared a technical policy brief on "Soil erosion status, priority treatment area and conservation measures for different districts of Arunachal Pradesh". This document focuses more on the severity of soil erosion areas by district, the state's soil erosion risk map with separate priority classes and its extent, unique issues, and soil and water conservation methods in addition to district-level agronomic, vegetative, and agroforestry measures.

I congratulate the team of ICAR-IISWC, Dehradun for their outstanding work in compiling the information in user's friendly mode benefitting various stakeholders involved in the dissemination of soil and water conservation measures through various watershed management schemes being implemented in the state.

(S.K. Chaudhari)

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PREFACE

The ICAR-Indian Institute of Soil and Water Conservation (IISWC), Dehradun is one of the national Institute of Natural Resource Management Division (NRM) of the Indian Council of Agricultural Research, Ministry of Agriculture and Farmer's Welfare, Government of India. The institute along with its eight research centres is constantly working for development of site-specific cost-effective soil and water conservation technologies, and it offers officers and graduate assistants of various state governments' specialised training in watershed management and soil conservation.

The discussions and recommendations of the research advisory council of the institute served as the basis for the preparation of this publication on "Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of Arunachal Pradesh". The committee emphasised the need for a strategy to check soil erosion and gave Arunachal Pradesh's sustainable development on top priority. The committee's recommendations and subsequent proposals led to the formation of a team at the institute made up of individuals from the Headquarter ICAR-IISWC, Dehradun.

Soil erosion is one of the most important environmental issues that affect both natural and man-made ecosystems. Soil erosion, in addition to having a considerable influence on cultivated land productivity, also has a negative impact on the chemical, physical, and biological functions of soil, leading to soil deterioration and depletion of many soil functions. Although soil erosion is a global phenomenon, it has become more severe in recent years as a result of population growth, developmental activities, and improper land use and land management practices. The risk of soil erosion is greater in Indian Himalayan states since many areas can no longer be supported for production, owing to high intensity rains, deforestation, overgrazing, forest fires, and incorrect land management practices, resulting in their abandonment. Around 56.81 % of the total geographical area (TGA), of Arunachal Pradesh experiences moderate or moderate to severe soil erosion loss.

In this context, the current technical brief on "Soil Erosion Status, Priority Treatment Areas and Conservation Measures for Different Districts of Arunachal Pradesh" can serve the purpose of ready-reckoner for the policy-planners. This technical brief is broadly divided into six chapters including photographs. The compiled information is mainly adapted from the previous work of the ICAR-IISWC and other similar institutes working in the field of soil erosion control in North-western Himalayan states. We sincerely acknowledge Director, ICAR-IISWC, Dehradun for providing all the necessary facilities and guidance to accomplish this endeavor successfully well on the time. We are equally

thankful to subject matter experts for their valuable guidance and cooperation. We are also thankful to other faculty members of Division of Soil Science and Agronomy for their help to complete this task successfully.

We not only hope but believe that this technical brief will be very useful for the stakeholders working on soil and water conservation. Mistakes and corrections are vital part of the any document, so comments and suggestions are always welcomed from the readers.

(Authors)

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1.0 INTRODUCTION

Soil erosion is one of the biggest environmental issues affecting all natural and human-managed ecosystems. In addition, soil erosion is having a significant negative impact on the productivity of cultivated land and also adversely affects the chemical, physical and biological functions of soil leading to degradation and depletion of numerous soil functions. Soil erosion despite being a global phenomenon, has intensified in recent years due to population pressures, developmental projects, improper and poor land use and land management practices.

The Northeastern Region of India, particularly due to its geographical location in the eastern Himalaya, exhibits unique features of hilly terrain and abundant rainfall with wide spatial variability. Due to inappropriate and unsustainable land-use practices along the steep hill slopes, the region is prone to severe water erosion and soil loss. The unsustainable land-use practices (including deforestation) in the undulating terrain, particularly in the land capability classes VI and VII under high rainfall occurrences, encourage severity of soil erosion *vis-à-vis* land degradation, hill-slope instability, and collapse of the mountain ecosystem. According to Mandal *et al.* (2020), 56.81 % of the total geographical area (TGA) of the state of Arunachal Pradesh undergoes moderate or moderate to severe soil erosion loss. Further, the average production loss of cereal and millets, oilseed and pulse crops due to water erosion were estimated to be 34%, 40% and 38%, respectively and consequently, average loss considering cereals, oil seeds and pulses combined is approximately 35% (Sharda and Dogra, 2013).

In an agrarian country like India, assessment of soil erosion risk is of paramount importance to preserve the soil's productive potential and ensure sustainable land use (Mandal and Giri, 2021; Sharda and Mandal, 2018). To check land degradation effectively below the permissible limit, land managers and policymakers need to have adequate knowledge of the intensity and distribution of soil erosion risk and accordingly plan and execute various cost-effective land-based interventions to achieve the targets of land degradation neutrality (LDN) (UNCCD, 2013). Hence, it is essential to quantify the risks associated with overuse of soil functions, which result in land degradation and subsequently affect eco-system services. This report provides a comprehensive overview of Arunachal Pradesh's district-level soil erosion issues along with appropriate soil and water conservation measures to arrest the problem. Land managers and farmers can use this report as a ready reference when addressing soil erosion issues in their region.

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). The average yearly decline in dam water storage capacity is 1.2% from 4937 large dams, and the average dam life lifetime is 25 years (range 8-53 years).

2.3 Production Loss and 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 ₹ 29200 crore during 2015-16 (Sharda and Dogra, 2013).

2.4 Nutrients Loss:

A significant amount (8 to 11 Mt 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 ₹ 13500- 29300, 1850-8320,17300 and 5890-7790 crore rupees (2020 price), respectively.

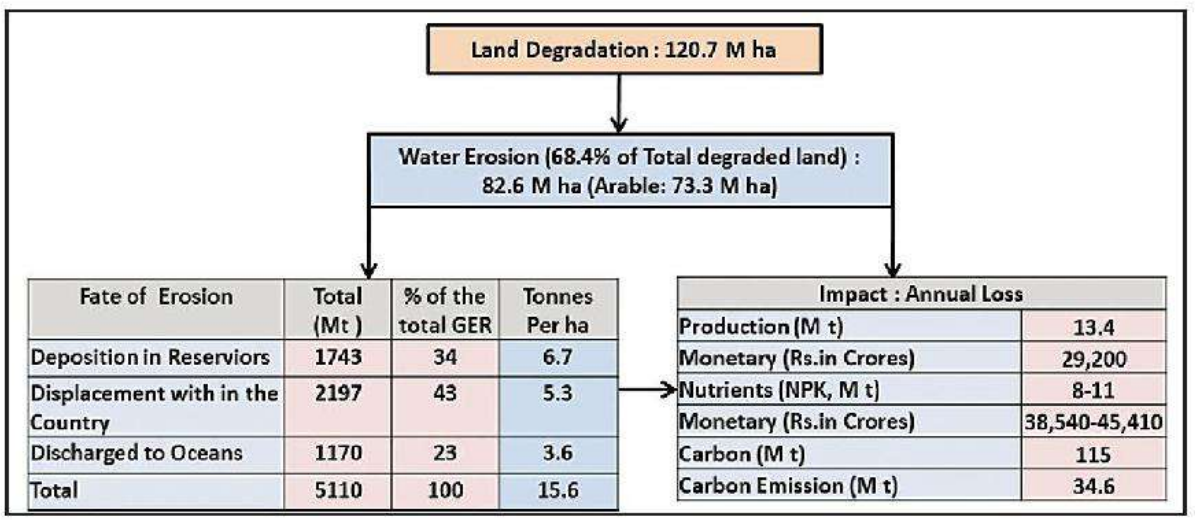
2.5 Carbon Loss:

Release of extra carbon dioxide into the atmosphere by organic matter dislodgement followed by decomposition has serious implications on climate change. The soil pool loses 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 Gm^3 was estimated at 1679 Mm^3 yr^{-1}, as a result of which the average annual capacity loss of the reservoirs was calculated as 1.04% with a range of 0.47 to 3.05% (Sharda and Ojasvi, 2016). Loss of gross storage capacity in the range of 0.50 % to 0.80% per year is experienced in the case of larger dams with capacity varying from 51 to >1000 Mm^3. Smaller dams of 1 to 50 Mm^3 capacity experience a reduction in storage capacity ranging from 0.80 % to > 2.00% per year. The annual total storage loss and dead storage loss in Sardar Sarovar dam has been estimated to be 0.495% and 1.27%, respectively resulting to annual capitalized loss of ₹ 1070 to 1137 million 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 (SLTL). While prevailing soil erosion rate is a function of physiographic, edaphic and climatic factors at a given location, the assessment of site-specific SLTL of the location helps in understanding the soil's capacity to endure the pressures 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) while soil erosion rates in such area is more than 10 t ha^{-1} yr^{-1}. Here, soil erosion rates exceed the SLTL, indicate need of soil erosion intervention.

The district wise prioritization/risk area was assessed from the data base on potential soil erosion rates and SLTLs for the state of Arunachal Pradesh. The potential soil erosion rate was compared with the value of soil SLTL, the differences in value of potential soil erosion and SLTL of a place was used for deciding priority class, higher the difference (Potential soil erosion rate – SLTL) means higher erosion risk, so get higher priority. Based on the difference of soil erosion and SLTL, 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 Arunachal Pradesh state an area of great concern from soil erosion point of view. For operational point of view the sum of priority class 1, 2 and 3 has been taken into consideration and the severity of soil erosion risk has been reclassified. According to this re-classification, severity class A, B and C were defined based on the cumulative area of < 50000 ha, 50000-100000 ha and > 100000 ha, respectively (Kannan et al. 2021).

Soil erosion in a given priority class has to be brought within the permissible rate or T-value to achieve sustainability of production systems, and for carbon sequestration. The identification of critical areas in the priority classes based on the permissible soil erosion rate or T-value at a given location in each district of Arunachal Pradesh 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 ARUNACHAL PRADESH

4.1 About the State

Arunachal Pradesh is administratively divided into 16 districts, 57 blocks, and 4065 villages covering 5 agro-climatic zones viz., Alpine zone, Temperate zone, Sub-tropical zone, Mid-tropical hill zone and Mid tropical plain zone (Table A1;Annexure 1). District-wise land use statistics and soil and water conservation, suspension bridge and rural housing in respect of Arunachal Pradesh as per latest agricultural census 2019-2020 (Table A2-A3; Annexure 1). Arunachal Pradesh is the state with the lowest population density in India. Agriculture is the primary source of the state's economy. Agriculture is the main occupation for about 35 percent of the population of Arunachal Pradesh. *Jhum* cultivation (Shifting Cultivation) and Terrace farming (Wetland Rice Cultivation (WRC)) are the two major patterns that farmers employ. The topography and climate of Arunachal Pradesh are conducive for the cultivation of rice, millets, wheat, maize, pulses, and potatoes. Horticulture is an important sector in Arunachal Pradesh and has tremendous potential for alleviating rural poverty. The total area suitable for horticulture is 1.8 Mha. However, the present total area under horticulture is only 0.088 Mha with a production of 0.12 MT. Horticulture comprises the cultivation of fruits such as apple, kiwi, walnut, orange, pine apple, litchi, lemon, ginger and banana. Forest is the most important resource in Arunachal Pradesh, with the predominantly large tribal population living in close association with forests and highly dependent on it. Arunachal Pradesh possesses India's second highest level of genetic resources. Although occupying only 2.5% of India's geographical area, the state occupies a significant place in terms of floral and faunal biodiversity, being considered one of the world's 18 biodiversity hotspots. Flood is a recurring phenomenon in the State due to high precipitation. An estimated 8155 sq. km area of the state is flood prone. The annual average rainfall of the state ranges from 300 mm to 7000 mm. Soils are generally shallow and occasionally moderately deep in plain areas, with rock outcrops in some areas. The soil depth of Arunachal Pradesh is shallow, covering 20 percent of the TGA of the state. Most of the state is covered by hills, and agricultural practices are limited to valley regions, however, the soils of other physiographic zones (lower altitudinal, moderately hilly terrain) provide scope for plantations, such as orange, banana and tea plantations.

4.2. Soil Erosion Rate:

A summary of the results for the state of Arunachal Pradesh is given in Table 4.1, which indicates that overall soil erosion through water is a serious problem in major parts of the state, as nearly

42.48% of the area has soil erosion of 25-35 t $ha^{-1}yr^{-1}$. Majority of these areas have a high slope, low soil depth (<1.5 m) and high drainage density, and therefore higher soil erosion risks. Soil erosion is affecting 53% of the state's TGA with erosion rates of 0-35 t $ha^{-1}yr^{-1}$. Soil erosion is more prevalent in hilly areas and in certain undulating pockets of the state where high intensity rainfall and steepness of slope has contributed to higher erosion rates (Mandal *et al.*, 2020).

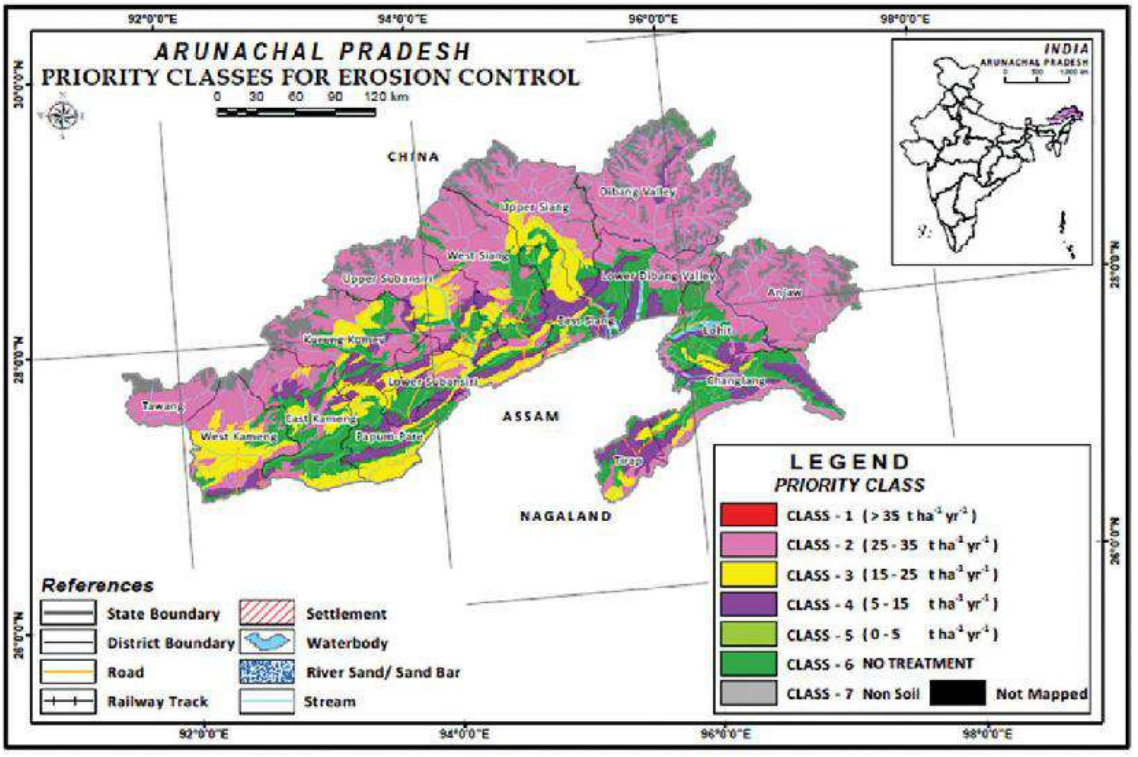


Fig. 4.1. Priority classes for erosion control in of Arunachal Pradesh

4.3. Soil Loss Tolerance Limit (SLTL):

Data pertaining to soil loss/erosion tolerance limits indicated that it varies between 2.5 and 12.5 t $ha^{-1}yr^{-1}$. The majority of the state's soil was covered by areas with medium to high T-values between 7.5 and 10.0 t $ha^{-1}yr^{-1}$. Of which soil with medium T-values are sensitive more and requires higher attention for adopting soil and water conservation measures to prevent further deterioration to low T-values. The state's Soil Loss Tolerance Limit map, which displays the various priority classes and their range, is shown in Fig. 4.2.

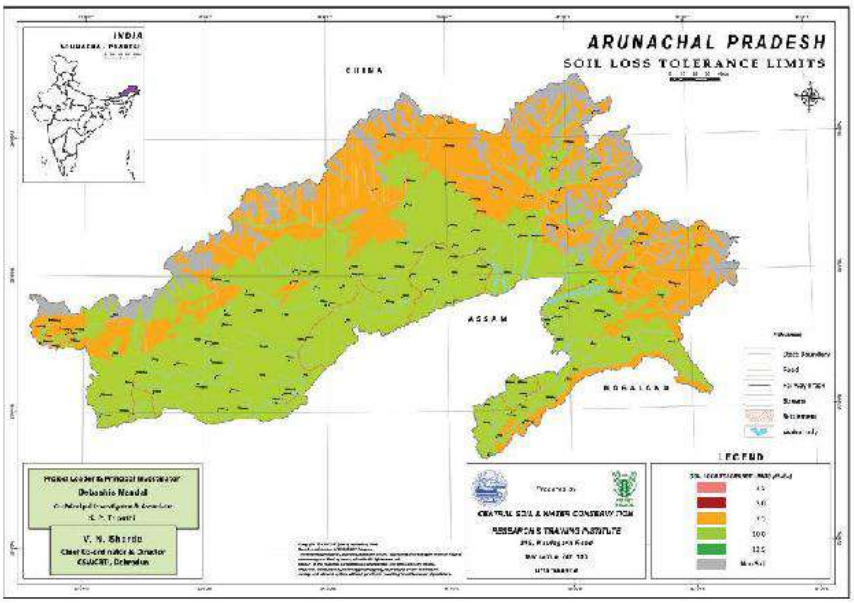


Fig. 4.2. Soil Loss Tolerance Limit map of Arunachal Pradesh State

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

The average production loss of cereal and millets, oilseed and pulse crops were estimated to be 34%, 40% and 38%, respectively, and consequently, average loss considering cereals, oil seeds and pulses together is about 35%. Out of 0.07 million tonne total production losses, 81.4% is due to losses in cereals and millets, 15.6% in oilseeds and 3.0% in pulses (Fig. 4.3). In terms of monetary losses, 63.5% of the total loss of ₹1646 million occurs in Arunachal Pradesh due to production losses in cereals and millets, followed by 29.2% in oilseeds and 7.3% in pulses (Fig. 4.4). The largest contribution is from paddy (32%) followed by rapeseed (22%), and maize (18%).

The productivity losses of cereal and millets, oilseed and pulse crops were estimated to be 408 kg ha^{-1}, 409 kg ha^{-1} and 304 kg ha^{-1}, respectively. The average productivity loss of all these crops together is 404 kg ha^{-1} (Sharda and Dogra, 2013), which in monetary terms was ₹9408 ha^{-1} during 2018-19 (Fig 4.5). The Gross State Domestic Product (GSDP) of Arunachal Pradesh for 2018-19 at current prices was estimated to be ₹24,603 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 0.67% of its GSDP during 2018-19.

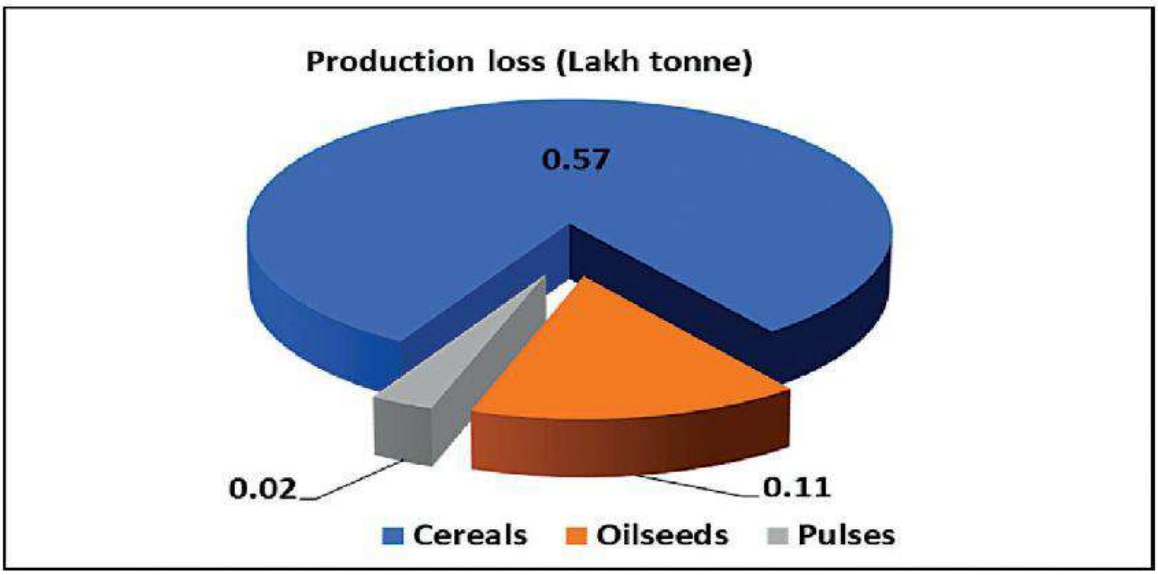


Fig. 4.3. Estimated total production loss of rainfed crops due to soil erosion in Arunachal Pradesh State

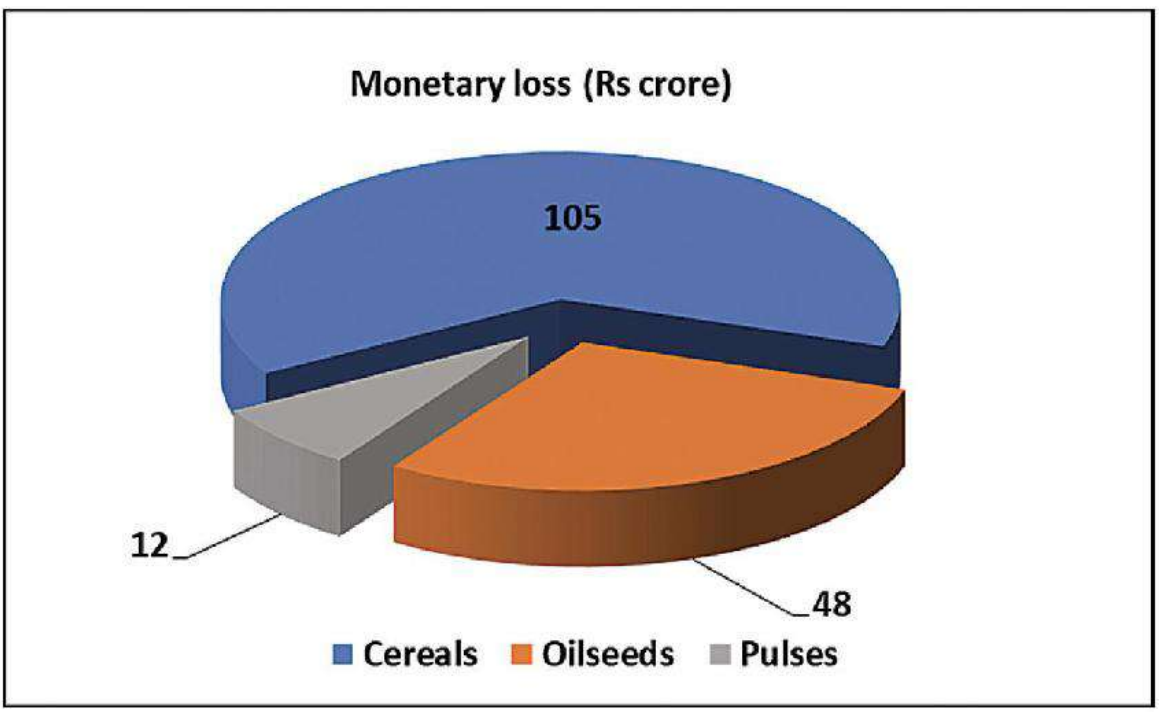


Fig. 4.4. Estimated total monetary loss (in ₹) of rainfed crops due to soil erosion in Arunachal Pradesh State

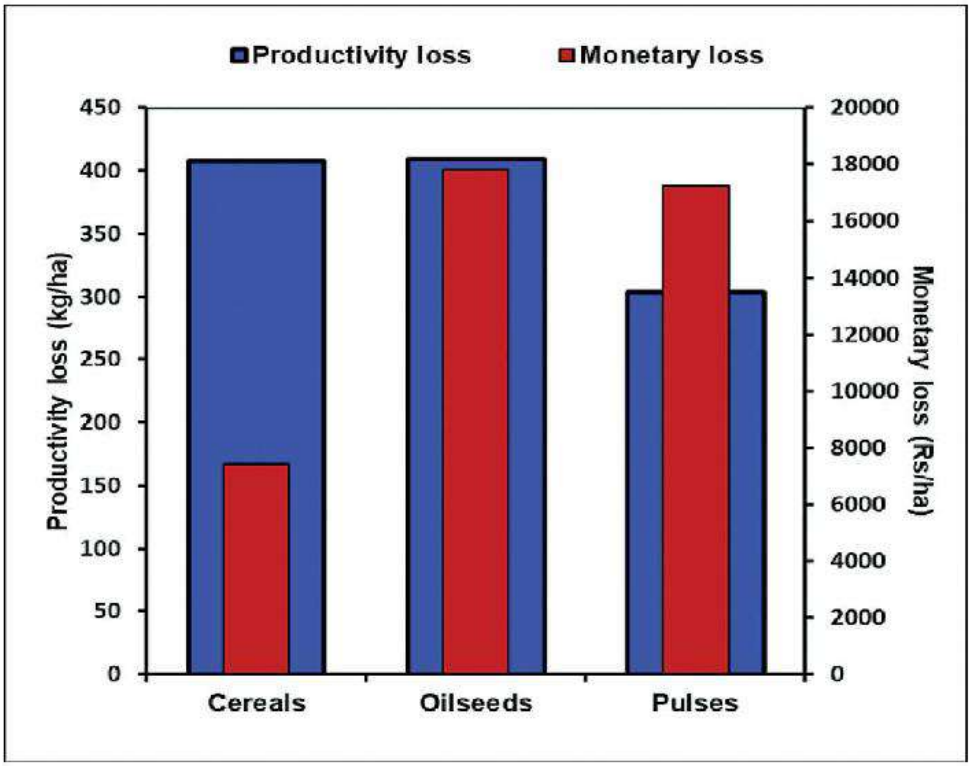


Fig. 4.5. Estimated productivity (kg ha^{-1}) and monetary loss [Rs ha^{-1}] of rainfed crops due to soil erosion in Arunachal Pradesh State.

4.5. Area under risk and treatment measures:

Delineating critical land degradation areas through prioritization process is crucial for developing open-space plans that protect soil and water resources, and in turn the ecosystems. Detail account of district wise severity of erosion areas and critical problem with their possible solutions has been given in Table 4.1. The last column of Table 4.1 refers Table 4.2 which is given in the succeeding sections of the document. Table 4.2 presents soil and water conservation engineering measures, under different land situations, Table 4.3 presents district wise agronomic and vegetative measures and Table 4.4 presents district wise agroforestry measures.

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

S N	District	TGA ('000'ha)	Area under risk ('000'ha)	% Area of the district	Special erosion problem	Solutions measures
Severity of Risk-A						
-Nil-						
Severity of Risk-B						
1	Tirap	214.37	77.12 (1: 0.0: 2: 44.73: 3:32.38)	35.98	Shifting cultivation (Jhoom), Very weak natural materials, Steep slope cuttings, Flash floods and drought, Unlined natural water channels, Landslide	Table 4.2-Sr No. 3.1.1, 3.1.3, 6.1.1, 6.1.5, 7.7
Severity of Risk-C						
2	East Siang	382.33	105.02 (1: 0.0: 2:14.77: 3:90.25)	27.47	Flood inundation and soil erosion, Siltation, landslides, deforestation and watershed degradation, Shifting cultivation (Jhoom)	Table 4.2- Sr No. 1.6, 3.1.1, 3.1.2, 3.2.1, 6.1.1, 6.1.5, 4.9, 7.7
3	Lohit	395.07	127.94 (1:0.0: 2:112.72: 3:15.22)	32.38	Shifting cultivation (*Jhoom*), Steep slope cuttings, Heavy siltation, landslides, deforestation and watershed degradation	Table 4.2- Sr No. 1.6, 3.1.1, 3.1.2, 3.2.1, 6.1.1, 6.1.5, 4.9, 7.7
4	Lower Subansiri	292.56	130.44 (1:0.0: 2:58.32: 3:72.12)	44.58	Flash flood inundation and soil erosion, Siltation, landslides, deforestation and watershed degradation Shifting cultivation (*Jhoom*)	Table 4.2-Sr No. 2.1, 3.1.1, 3.1.3, 3.2.1, 6.1.1, 6.1.5, 7.7
5	Papum-Pare	387.06	158.13 (1:0.0: 2:12.32: 3:145.80)	40.85	Shifting cultivation (*Jhoom*), Steep slope cuttings, Heavy siltation, landslides, deforestation and watershed degradation	Table 4.2- Sr No. 4.9, 1.6, 3.1.1, 3.1.2, 3.2.1, 7.7, 6.1.1, 6.1.5
6	Changlang	506.07	161.72 (1:0.0: 2:123.97: 3:37.74)	31.96	Very weak natural materials, Steep slope cuttings, Flash floods and drought, Unlined natural water channels, Landslide	Table 4.2- Sr No. 1.6, 3.1.1, 3.1.2, 3.2.1, 6.1.1, 6.1.5, 7.7, 4.9
7	Tawang	220.82	170.61 (1:0.0: 2:170.61: 3:0.0)	77.26	Flash flood inundation and soil erosion, Siltation, landslides, deforestation and watershed degradation, Shifting cultivation (Jhoom)	Table 4.2- Sr No. 4.9, 3.1.1, 3.1.2, 3.2.1, 7.7, 6.1.1, 6.1.5, 1.6, 6.1.7
8	Lower Dibang Valley	402.53	170.76 (1:0.0: 2:169.96: 3:0.80)	42.42	Landslides, deforestation and watershed degradation, Flash flood inundation and soil erosion, Siltation, Shifting cultivation	Table 4.2- Sr No. 4.9, 1.6, 3.1.1, 3.1.2, 3.2.1, 7.7, 6.1.1, 6.1.5, 6.1.3
9	East Kameng	606.14	295.17 (1:0.0: 2:185.19: 3:109.97)	48.70	Shifting cultivation (Jhoom), Steep slope cuttings, Heavy siltation, landslides, deforestation and watershed degradation	Table 4.2- Sr No. 4.9, 3.2.1, 7.7, 7.11, 6.1.1, 6.1.5, 1.6, 6.1.7, 3.1.1, 3.1.2

10	Kurung Kumey	650.81	349.43 (1:0.0; 2:234.14; 3:115.29)	53.69	Heavy siltation, Flash flood inundation and soil erosion, landslides, deforestation and watershed degradation Shifting cultivation	Table 4.2- Sr No. 4.9, 1.6, 3.1.1, 3.1.2, 3.2.1, 7.7, 6.1.1, 6.1.5, 6.1.3, 7.11
11	West Kameng	557.15	426.39 (1:0.0; 2:226.86; 3:199.53)	76.53	Very weak natural materials, Steep slope cuttings, Flash floods, Unlined natural water channels, Loading of weak slopes by heavy constructions	Table 4.2- Sr No. 4.9, 3.2.1, 7.7, 7.11, 6.1.1, 6.2.4, 3.1.1, 3.1.2
12	Upper Subansiri	652.97	459.68 (1:0.0; 2:323.68; 3:135.99)	70.40	Landslides, deforestation and watershed degradation, Shifting cultivation, Steep slope cuttings, Heavy siltation	Table 4.2-Sr No. 3.1.1, 3.1.3, 6.1.1, 6.1.5, 7.7, 7.11
13	Anjaw	667.08	503.17 (1:0.0; 2:503.16; 3:0.0)	75.43	Shifting cultivation,Steep slope cuttings, Heavy siltation, landslides, deforestation and watershed degradation	Table 4.2- Sr No. 4.9, 3.2.1, 7.7, 7.11, 6.1.1, 6.2.4, 3.1.1, 3.1.2
14	West Siang	809.58	512.98 (1:0.0; 2:389.93; 3:123.04)	63.36	Heavy siltation, Shifting cultivation, Steep slope cuttings, landslides, deforestation and watershed degradation	Table 4.2- Sr No. 3.2.1, 7.7, 6.1.1, 6.2.4, 3.1.1, 3.1.2
15	Upper Siang	691.31	525.81 (1:0.0; 2:404.41; 3:121.40)	76.06	Steep slope cuttings, Heavy siltation, landslides, Shifting cultivation, deforestation and watershed degradation	Table 4.2-Sr No. 3.1.1, 3.1.3, 6.1.1, 6.1.5, 7.7, 7.11
16	Dibang Valley	938.45	583.43 (1:0.0; 2:583.42; 3:0.0)	62.17	Flash flood inundation and soil erosion, Shifting cultivation, Steep slope cuttings, Heavy siltation, landslides, deforestation and watershed degradation	Table 4.2- Sr No. 3.2.1, 7.7, 7.11, 6.1.1, 6.2.4, 3.1.1, 3.1.2, 4.9
	Total	8374.30	4757.79	56.81		

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 (E_r) 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 engineering measures for different land situations.

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)**				
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/ strip cropping	√		√	
1.8	Fodder/ tea/ medicinal-aromatic crops on the terrace riser			√	
1.9	Ridge and furrow (Deep soils)	√			
1.10	Dead Furrow opening in between the crop lines (Deep soils)	√			
1.11	Horticulture: Cultivationof vegetables / spices	√		√	
1.12	Emplacement of Coir/jute geotextiles on contours	√		√	
2.0	**Vegetative measures (At lower slope-alone, at higher slope with other conservation measures**				
2.1	Vegetative barrier*	√	√	√	√
2.2	Agri-horticulture		√	√	√
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: Bajra Napier (BN) hybrid, guinea grass, setaria, sorghum, maize, oat, cowpea, guar, *Melia azedarach, Morus alba, Ulmus wallichiana, Morus serrata, Bauhinia variegate, Leucaena leucocephala*				
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 (DLT's)**				
4.1	Earthen Check dam		√		
4.2	Sandbag check dam (Katta-carat)		√		
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/Ooranics	√	√	√	
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				√
6.1.10	Geo-textiles		√		√
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: District wise details of agronomic and vegetative measures for Arunachal Pradesh is referred in Table 4.3

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

Note 3: For Agroforestry solution for soil water conservation in Arunachal Pradesh kindly refer Table 4.4

Table 4.3. District wise area under various erosion risk and the possible agronomic and vegetative measures for Arunachal Pradesh

[District Details: Name of District, Total Geographical area, TGA (000, ha), Area under erosion risk (A(Er)) ('000 ha), erosion risk area as a percentage of TGA (Er(%)), Special erosion problem (Sp.P)]				
S. N.	**Cropping System (Intercropping, mixed cropping, Conservation Agriculture, crop rotation, etc.)**	**Green manuring, Cover crops and Mulching**	**Protection-cum Productive Vegetative Barriers (Grasses/Fodder/Medicinal-Aromatic Crops /Tea/ etc.)**	**Special problem area: Grassed waterways/live check dams/Mine spoil area/ Land Slide Prone Area**
	Severity of Risk-B			
1.	**Tirap, TGA:214.36, A(Er): 77.11, (Er(%)): 35.97%, Sp.P: Landslide, Flash floods and drought**			
	•Ginger, Large Cardamom, Mustard cultivation with furrow system • Rice-Maize- Maize + Cowpea	•Green manuring with Cowpea •Leaf litter mulch for moisture conservation and to improve fertility	• *Salix alba, Morus serrata, Morus alba, Bauhinia variegate* and *Ulmus wallichiana*	• Culvert with sluice • Afforestation with the following species –*Grewia spp. Morus spp, Bamboo, Bauhinia variegate*
	Severity of Risk-C			
2.	**East Siang, TGA: 382.33, A(Er): 105.01, (Er(%)) 27.46%, Sp.P: Shifting cultivation, Steep slopes, Deforestation, Siltation**			
	•Horti-pasture Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover • Rice, Maize, wheat, Millet. Potato, Chilli, Ginger, Large Cardamom•Soil fertility management •Green manuring with Cowpe, Cluster bean•Leaf litter mulch for moisture conservation and to improve fertility	•Green manuring with Cowpe, Cluster bean •Leaf litter mulch for moisture conservation and to improve fertility	• *Grewia optiva, Celtis australis, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck, Morus alba* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum*	• Culvert with sluice • Afforestation with the following species – *Grewia spp., Celtis australis, Morus spp, Albizzia spp., Bamboo,* Apricot, Peach, Plum
3.	**Lohit, TGA: 395.07, A(Er): 127.93, (Er(%)) 32.38%, Sp.P: Shifting cultivation, landslides**			
	• Ginger, Large Cardamom, Mustard cultivation with furrow system • Horti-pasture Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover • Rice-Maize- Maize +Cowpea Maize (Baby corn)- Oats-Maize (Baby corn)	• Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Ulmus wallichiana, Salix alba, Morus serrata, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck, Bauhinia variegata* • *Dicanthium annulatum, Chrysopogon montanus, Lolium multiflorum, Chrysopogon fulvus, Festuca arundinacea, Dactylis glomerata, Phleum alpinum*	• Culvert with sluice • Afforestation with the following species–*Salix alba, Ulmus wallichiana, Albizzia spp., Morus serrata,* Apricot, Peach, Plum
4.	**Lower Subansiri, TGA: 292.56, A(Er): 130.43, (Er(%)) 44.58%, Sp.P: Flash flood inundation and soil erosion, deforestation and watershed degradation**			
	• Horti-pasturePlum/Litchi/Peach+ Guinea/Setaria+ S. hamata	•Green manuring with Cowpea, Cluster bean	• *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis,*	• Culvert with sluice • Afforestation with the following species–*Grewia spp., Celtis australis, Morus*

	• Wheat+ Mentha intercropping•Soil fertility management	• Leaf litter mulch for moisture conservation and to improve fertility	*Albizzia lebbeck, Morus alba,* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata, Tall fescue*	*spp., Bamboo, Leucaena leucocephala*
5.	**Papum-Pare, TGA: 387.06, A(Er):158.12, (Er(%)) 40.85%, Sp.P: Steep slope cuttings, Heavy siltation**			
	• Maize+Cowpea- Oat+Fodder Mustard- Sorghum + Cowpea BN Hybrid+	• Green manuring with Cowpea, Cluster bean• Leaf litter mulch for moisture conservation and to improve fertility	• *Ulmus wallichiana, Salix alba, Morus serrata, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck, Bauhinia variegata* • *Dicanthium annulatum, Chrysopogon montanus, Lolium multiflorum, Chrysopogon fulvus, Festuca arundinacea, Dactylis glomerata, Phleum alpinum*	• Culvert with sluice • Afforestation with the following species –*Ulmus wallichiana, Salix alba, Morus serrata, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck, Bauhinia variegata*
6.	**Changlang, TGA: 506.07, A(Er): 161.71, (Er(%)) 31.95%, Sp. P: Flash floods and drought, Landslide**			
	• Maize+Cowpea- Oat+Fodder Mustard- Sorghum + Cowpea BN Hybrid+	• Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Ulmus wallichiana, Salix alba, Morus serrata, Morus alba, Bauhinia variegata* • *Chrysopogon montanus, Lolium multiflorum, Chrysopogon fulvus, Festuca arundinacea, Dactylis glomerata, Phleum alpinum, Stipa spp., Chrysopogon grullus*	• Culvert with sluice • Afforestation with the following species – *Salix alba, Morus serrata, Morus alba, Bauhinia variegata*
7.	**Tawang, TGA: 220.81, A(Er): 170.60, (Er(%)) 77.26%, Sp.P: Flash flood inundation and soil erosion, Siltation**			
	•Horti-pasture Apple/Apricot/ Peach+ Tall fescue /Orchard grass + White /Red Clover • Ginger cultivation with furrow system •Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis, Albizzia lebbeck, Morus alba,* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata, Tall fescue*	• Culvert with sluice • Afforestation with the following species –*Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba, Apple, Apricot, Peach*
8.	**Lower Dibang Valley, TGA: 402.53, A(Er): 170.76, (Er(%)) 42.42%, Sp.P: Flash flood inundation and soil erosion, siltation**			
	• Horti-pasture Apple/Apricot/ Peach+ Tall fescue /Orchard grass + White /Red Clover • Ginger cultivation with furrow system	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis, Albizzia lebbeck, Morus alba* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata, Tall fescue*	• Culvert with sluice • Afforestation with the following species – *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba,* Apple, Apricot, Peach
9.	**East Kameng, TGA: 606.14, A(Er): 295.17, (Er(%)) 48.69%, Sp.P: Shifting cultivation, Steep slope cuttings**			
	• Horti-pasture Apple/Apricot/ Peach+ Tall fescue /Orchard grass + White /Red Clover	Green manuring with Cowpea, Cluster bean• Leaf litter mulch for moisture conservation	• *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis, Albizzia lebbeck, Morus alba,*	• Culvert with sluice • Afforestation with the following species – *Grewia optiva, Celtis australis,*

	• Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover	and to improve fertility	• *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata, Tall fescue*	*Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba*, Apple, Apricot, Peach
10.	**Kurung Kumey, TGA: 650.81, A(Er): 349.43, (Er(%)) 53.69%, Sp.P: Shifting Steep slope cuttings, Heavy siltation, landslides**			
	• Horti-pasture Apple/Apricot/ Peach+ Tall fescue /Orchard grass + White /Red Clover • Ginger cultivation with furrow system	• Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis, Albizzia lebbeck, Morus alba,* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata, Tall fescue*	• Culvert with sluice • Afforestation with the following species – *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba*, Apple, Apricot, Peach
11.	**West Kameng, TGA: 557.14, A(Er): 426.39, (Er(%)) 76.53%, Sp.P: Steep slope cuttings, Flash floods, Unlined natural water channels**			
	• Horti-pasture Apple/Apricot/ Peach+ Tall fescue /Orchard grass + White /Red Clover	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Grewia optiva, Celtis australis, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck, Morus alba,* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata*	• Culvert with sluice • Afforestation with the following species – *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba*, Apple, Apricot, Peach
12.	**Upper Subansiri, TGA: 652.96, A(Er): 459.67, (Er(%)) 70.39%, Sp.P: Landslides, deforestation and watershed degradation, Shifting cultivation**			
	• Horti-pasture Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	*Grewia optiva, Celtis australis, Morus alba, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata*	• Culvert with sluice • Afforestation with the following species – *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba, Plum*, Apricot, Peach
13.	**Anjaw, TGA: 667.07, A(Er): 503.16, (Er(%)) 75.42%, Sp.P: Steep slope cuttings, Heavy siltation, landslides, deforestation and watershed degradation**			
	• Paddy – green manuring crops • Ginger cultivation with furrow system	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis, Albizzia lebbeck, Morus alba* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Panicum maximum, Dactylis glomerata, Tall fescue*	• Culvert with sluice • Afforestation with the following species – *Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia chinensis, Albizzia lebbeck, Morus alba*

14.	**West Siang, TGA: 809.57, A(Er): 512.97, (Er(%)) 63.36%, Sp.P: Heavy siltation, landslides, deforestation**			
	• Horti-pasture Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover	Green manuring with Cowpea, Cluster bean• Leaf litter mulch for moisture conservation and to improve fertility	*Grewia optiva, Celtis australis, Morus alba, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Tall fescue, Panicum maximum, Dactylis glomerata*	• Culvert with sluice • Afforestation with the following species – *Grewia optiva, Celtis australis, Leucaena leucocephala, Melia azedarach, Albizzia spp., Morus alba, Plum,* Apricot, Peach
15.	**Upper Siang, TGA: 691.30, A(Er): 525.81, (Er(%)) 76.06%, Sp.P : Steep slope cuttings, Heavy siltation, landslides, Shifting cultivation**			
	• Horti-pasture Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	• *Ulmus wallichiana, Salix alba, Morus serrata, Morus alba, Bauhinia variegata* • *Chrysopogon montanus, Lolium multiflorum, Chrysopogon fulvus, Festuca arundinacea, Dactylis glomerata, Phleum alpinum, Stipa spp., Chrysopogon gryllus*	• Culvert with sluice • Afforestation with the following species – *Ulmus wallichiana, Salix alba, Morus serrata, Morus alba, Bauhinia variegate, Peach, Plum, Apricot*
16.	**Dibang Valley, TGA: 938.44, A(Er): 583.42, (Er(%)) 62.16%, Sp.P: Flash flood inundation and soil erosion**			
	• Horti-pasture Peach/Plum/Apricot+ Rye grass/Tall fescue+ White clover	Green manuring with Cowpea, Cluster bean • Leaf litter mulch for moisture conservation and to improve fertility	*Grewia optiva, Celtis australis, Morus alba, Leucaena leucocephala, Albizzia chinensis, Albizzia lebbeck* • *Dicanthium annulatum, Chrysopogon fulvus, Lolium perenne, Setaria grass, Tall fescue, Panicum maximum, Dactylis glomerata*	• Culvert with sluice • Afforestation with the following species – *Grewia spp. Morus spp, Leucaena leucocephala, Albizzia spp., Peach, Plum,* Apricot
	TGA (000 ha):8374.30, Area under Severity of risk A: 4757.79, % of TGA under risk: 56.81			

Source: Fodder Resources Development Plan for Arunachal Pradesh (2022). ICAR-Indian Grassland and Fodder Research Institute, Jhansi.

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 50,000-1,00000 ha area is critical; Severity Risk 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 (E_r) 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 engineering measures for different land situations and Table 4.4 represents district wise potential agroforestry systems (AFS).

Table 4.4. Common agroforestry practices for soil water conservation under different altitudes of Arunachal Pradesh

Altitude (msl*)	Agroforestry practices	Details
1500-3500m	Pine with field and vegetable crops Plum with vegetables Pears with vegetables and broom grass Apple with field and vegetable crops Alder with food crop	Pine trees with seasonal vegetablesPine trees with broom grassPlum with seasonal vegetablesPear with seasonal vegetablesApple with potato, barley, bean, cabbage ginger, turmeric and radishSoybean + mustard + kiwi + strawberry
500 to 1500 m	*Albizia/Ficus* with rhizomatous crops *Ficus* spp. /Makri Sal with large cardamom *Ficus/Bauhinia* with broom and napier *Albizia/Ficus/Grewia/Artocapus* with food crops Makrisal + pineapple Makrisal + ginger + turmeric Mandarin with pineapple/ Vegetable cropsGuava, banana and drumstickBamboo + Litsea cubeba + cardamomTea + guava+Pandanus sp.+ jackfruit + bamboo + Magnolia champaca Bauhinia variegata + bamboo + cardamom + colocasia Cardamom + orange + pineapple + Livistona jenkinsiana + Phoebe sp. + hillock	Ficus/Albizia with ginger, turmeric and taro Albizia/Ficus/Grewia/Artocarpus with maize, cowpea, upland paddy and millet Mandarin with pineapple/beans/radish/ginger/ turmeric/Cole crops etc. Intercrops, viz, maize-wheat: maize-ginger/ buckwheat/millet/pulses/vegetables: ginger/rice bean: maize/ sweet potato Mustard + cabbage + kiwi + strawberry Vegetable crops + multipurpose trees around or near fish ponds
0 to 500 m	Mandarin+ crops Areca nut + pineapple + betel vine + black pepper Banana + pineapple *Terminalia* + coffee + black pepper Strawberry + beans + Citrus sp. Jackfruit + peach + chilli + colocasia + beans Mango + potato + beans + colocasia + pineapple *Livistona jenkinsiana* + arecanut+ black pepper	Intercrops *viz*, beans, chillies, ginger and turmeric Rice + fish farming Rice + maize + beans on the bunds of rice fields Arecanut, jackfruit and banana etc. around fish pond in homestead

*above Mean Sea level

Source: Bhatt *et. al.*, 2001; Bani *et. al.*, 2022

5.0 CONCLUSION

The hilly areas of Arunachal Pradesh, which occupies a major portion in the North-eastern Himalayan region is relatively a younger formation and geologically, a very complex range. It covers an area of about 84,000 km^2 with elevation ranging from 400 to 6,000 m above the mean sea level (Satpathy and Dutta 1999). Land degradation due to water erosion is a usual phenomenon in most part of Arunachal Pradesh due to the ruggedness of terrain and prevailing climatic conditions. As per the Desertification report by Space Application Centre, Ahmedabad, this state is also facing a rapid rate of desertification which increased by 46 % between 2003-05 to 2018-19 (https://www.downtoearth.org.in/news/climate-change/india-s-northeastern-states-desertifying-most-rapidly-78695). The current situation in the State requires very meticulous planning and execution of different nature positive soil and water conservation measures to balance the negative impacts of land degradation and conserve natural resources. A wide range of soil and water conservation measures including agronomic and vegetative measures for different land situations and agroforestry measures for different districts have been suggested in the present compilation. The suggested measures aim reducing soil erosion below the soil loss tolerance limit of the area. The uniqueness of the present approach is that it integrates soil erosion risk areas with production losses of major crops. This approach would immensely benefit land use planners and policy makers to identify and prioritize the areas, for execution of site-specific best management practices and bring soil erosion rates within the permissible limits, thus saving on scarce financial resources.

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PHOTOGRAPHS

Photo 1: Land slide and mass soil erosion, Photo 2:Dumping of plastic wastes in the hills; Photo 3 & 4: Different soil and water conservation measures in practice: Fig 5: Felling of trees for Jhoom cultivation

Photo 6 & 7: Forest area cleared for Jhoom cultivation, Photo 8:Degraded pine forest ; Photo 9&10: Mass erosion induced by anthropogenic interferences

Annexure-I

Table A1: Agro-climatic zones of Arunachal Pradesh

S. No	Agroclimatic zone	Climate conditions	Area under zone	Major land use
1	Alpine zone	Annual precipitation 2000 mm, mean temp. of coldest month <0°C, Winter months 4-5, Dry months 5-6	Gourichen, Upper Tawang, Tulungla, Shele pass areas of West Kameng district, Jidu and adjoining area of Northern Siang	Pasture land, jhum cultivation, Lower parts of alpine zone from the upper limit of potato cultivation
2	Temperate zone	precipitation 2000 mm, mean temp. of coldest month <10°C, Winter months 1-2, Dry months 4, High humidity	Tawang, Dirang, Bomdila, Shergaon area of West Kameng district of Dibang vally, Northern parts of East Siang, Upper Subansiri, parts of West Siang, around Anini and North Eastern part of Lohit district	Jhum prominent Upper limit of successful dry maize, rice/millet.
3	Sub-tropical zone	precipitation 2000-4000 mm, mean temp. of coldest month <15°C, High humidity, Dry months 3-4	Changlang, Naga & Khonsa areas of Tirap district, Basar areas of Siang district.	Wet rice, low intensity of jhum
4	Mid-tropical hill zone	precipitation 2500-5500 mm, mean temp. of coldest	Southern part of lower Subansiri district	Wet rice cultivation

		month <20°C,		
5	Mid tropical plain zone	High humidity, Dry months 2-3	Pasighat area, Singphow areas of Tirap district and Lower part of Lohit district	

Based on: Borthakar, D.N., 1992; Kaul and Haridasan, 1987; Sundriyal, 2001

Source: Agroforestry system and practices prevailing in Arunanchal Predesh, their constraints and potentials. Sood, K.K., Handique, P. and Singh, B. 2007

Table A2: District-wise land use statistics in respect of Arunachal Pradesh as per latest agricultural census 2019-2020 (Area in ha)

Sl. No	Districts	Operational		Net Area Sown	Current fallow land excluding fallow land	Unculti vated land than current flan allow	Fallow land other land	Cultiv able waste for cultiva tion	Land not available	Gross cropped Area		Net irrigated Area
		No	Area							Irriga ted	Un-irrigated	
0	1	2	3	4	5	6	7	8	9	10	11	12
1.	Tawang	4870	4295.26	3259.66	622.639	412.961	1249.0	1356.0	1322.0	23.96	4839.9	23.0
2.	West Kameng	5343	11764.6	11519.6	162.3	82.6	1558.0	3684.0	1530.0	2116.9	11375.1	2116.8
3.	East Kameng	5685	20844.4	15553.2	1549.6	3741.5	5924.0	1228.0	1392.0	950.7	22103.7	935.3
4.	Papum Pare	4887	18992.1	12864.7	1404.3	4723.0	1982.0	2887.0	2374.0	2098.0	14033.5	2083.9
5.	Lower Subansiri	10071	16828.0	8742.3	316.3	7769.4	1191.0	1048.0	1522.0	2538.7	11006.7	2514.7
6.	Kar-Daadi	7162	20595.0	10075.6	1086.6	9432.7	472.0	1524.0	704.0	2779.3	11123.8	2750.4
7.	Kurun Kumey	4033	14182.6	6941.8	1469.1	5771.5	593.0	1874.0	861.0	3069.3	6145.8	3064.1
8.	Upper Subansiri	8396	42237.3	20135.8	3787. 389	18314. 063	5546. 000	5508. 000	6662. 000	5826. 558	19861. 913	5803.3
9.	West Siang	11391	37048.9	13396.8	5351.2	18300.8	2872.0	2195.0	4873.0	2771.567	17208.8	2737.7
10.	Upper Siang	4361	15521.8	8168.9	848.1	6504.7	1410.0	6256.0	1588.0	3483.5	6678.8	3474.4
11.	East Siang	4180	22812.7	9571.3	5549.0	7692.3	2112.0	4409.0	3955.0	3538.3	10563.7	3454.8
12.	L/ Dibang Vally	1725	12627.3	8290.7	1502.3	2834.3	1463.0	1838.0	932.0	3695.0	6559.2	3687.5
13.	Dibang Valley	2073	9453.1	4972.3	1419.8	3060.8	1613.0	795.0	642.0	1406.5	5947.7	1398.0
14.	Lohit	1676	11408.7	9864.3	925.9	618.5	1210.0	1079.0	1478.000	4576.9	6786.3	4576.8
15.	Anjaw	2936	8697.8	6987.3	358.164	1352.3	1822.0	6310.0	1349.0	1101.6	8429.6	1101.2
16.	Namsai	6388	13685.4	7147.4	1805.3	4732.5	1853.0	1643.0	2217.0	2080.7	8551.0	2061.8
17.	Changlang	14134	43907.4	34315.2	4018.6	5573.6	7622.0	1498.0	23728.0	4139.6	41180.0	4107.3
18.	Tirap	1527	11027.5	7073.1	2569.4	1384.9	9184.0	5153.0	671.0	5175.4	3074.3	5170.5
19.	Longding	7309	21789.7	15766.4	3299.4	2723.8	11217.0	6322.0	858.0	1859.3	20909.3	1761.8
20.	Siang	5106	22218.5	11431.7	2816.7	7970.0	1844.0	2610.0	3321.0	3434.6	10492.3	3379.8
	Total A. P	**113253**	**3799 39.0**	**2260 79.0**	**408 62.9**	**1129 97.0**	**627 37.0**	**610 17.0**	**619 79.0**	**566 67.1**	**2468 72.1**	**562 22.0**

Source: Directorate of Agriculture, Govt. A.P, Naharlagun

Table A3: District-Wise soil and water conservation, suspension bridge and rural housing in Arunachal Pradesh during the year 2019-20

S. No.	Name of District	Division	Soil and Water Conservation		Suspension bridge (in Nos)
			Land development (ha)	Land protection (ha)	
1	**2**	**3**	**4**	**5**	**6**
1.	West Siang	Aalo	-	-	5
2.	Shi Yomi	Mechuka	-	-	55
3.	Lepa Rada	Basar	-	-	14
4.	Upper Siang	Yingkiong	-	-	12
5.	Siang	Kaying	-	-	23
6.	Lower Siang	Likabali	-	-	6
7.	East Siang	Pasighat	-	-	8
8.	Dibang Valley	Anini	-	-	6
9.	L/Dibang Valley	Roing	-	-	3
10.	Anjaw	Hawai	-	-	57
11.	Lohit	Tezu	-	-	4
12.	Namsai	Namsai	-	-	5
13.	Changlang	Changlang	-	-	54
14.	Khonsa	Khanglang	-	-	7
15.	Longding	Longding	-	-	4
16.	Tawang	Tawang	199	-	17
	Lumla	-	13		
17.	West Kameng	Singchung	-	-	37
18.	East Kameng	Seppa	515	-	13
	Bameng	-	34		
19.	Pakke Kessang	Pakke Kessang	-	-	6
20.	Papum Pare	Poma	448	-	37
	Sagalee	-	15		
21.	Lower Subansiri	Ziro	514	-	15
22.	Kurung Kumey	L/Yange	-	-	82
23.	Kar Dadi	Jamin	-	-	30
24.	Kamle	Raga	-	-	4
25.	Upper Subansiri	Daporijo	-	-	17
	Total	-	-	-	**583**

Source: Chief Engineer, RWD, Arunachal Pradesh, Itanagar.

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