

Traditional soil and water conservation by tribal farmers in Arunachal Pradesh: A case study on erosion control

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Mountainous regions require more attention to protect, restore, and develop than any other ecosystems. Prioritizing techniques and practices that improve productivity while protecting the environment is essential in this regard. A study was conducted to identify traditional agricultural practices and soil and water conservation measures among *Galo* tribal farmers in Arunachal Pradesh, India. Data were gathered through surveys, group discussions, interviews, and field observations from 150 farmers across three elevation zones (low, medium, and high) during 2022-23. Farmers have inherited and implemented various conservation practices, including wetland rice cultivation (*Esiarik*), contour farming, mulching, agroforestry, vegetative barriers, bamboo channel irrigation systems (*Kombo*), mixed crops, water-harvesting structures, and traditional soil conservation methods. This study documents and analyses the elevation-specific indigenous conservation practices of *Galo* tribal farmers. These practices are widespread across all elevation zones, indicating farmers' strong reliance on traditional conservation methods and their economic benefits. The outcomes of this study have significant implications for regional strategies related to sustainable land management.

Keywords: Arunachal Pradesh, Land management, Soil and water conservation, Soil erosion, Traditional knowledge, Tribal farmers

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Water and soil sustain agriculture and ensure environmentally friendly practices in all regions. However, in hilly regions such as Arunachal Pradesh, these resources face increasing threats from soil erosion, which presents significant challenges for sustainable land use. The exploding population puts immense pressure on food, fibre, and shelter resources. To reduce environmental pollution and soil degradation, soil and water conservation measures are necessary to ensure sustained land productivity over time^{1,2} and maintain agricultural output and plant growth. Communities worldwide have developed both conventional and modern methods to conserve soil and water over time, considering issues such as climate change and achieving sustainable development goals.

Mountain watersheds are receiving worldwide attention because of their potential for significant environmental and socioeconomic consequences

resulting from the degradation of natural resources³. Northeast India is known for its unique topography, significant elevation and slope differences, diverse land tenure systems, and delicate ecosystem. The economic growth of this region is largely dependent on how wisely it uses its natural resources, which are primarily water and soil. Arunachal Pradesh is the largest state in the northeastern region, covering approximately 8.37 million hectares. Owing to its high annual rainfall (1380-5000 mm) and mountainous topography (approximately 94.6% of the region), the Northeastern highlands experience substantial rainfall loss owing to runoff^{4,5}. Unfortunately, this area is experiencing significant ecological degradation due to poor land use and conservation methods. The region's total land area comprises 0.96 million hectares of degraded land, which accounts for 11.74%⁶. In hilly areas, human activities such as deforestation, vegetation burning, urban growth, mining, stone quarrying, and unsustainable agricultural practices (sedentary or

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established agriculture and *Jhum*), contribute to soil erosion. *Jhum*, a traditional agricultural practice widespread among the agricultural tribal population in the NEH region, is the primary source of income. Hill farmers use *Jhum* cultivation to maximize natural resources and minimize cultivation risks by using slashing, clearing, and burning techniques from January to March⁷.

Jhum farmers cultivate cereals, legumes, oilseeds, root crops, cucurbits, and seeded vegetables, as well as fruits, cash crops, and spices. This cultivation continues for one to two years until soil fertility declines⁸. The *Jhum* cycle involves a 10-20 year fallow period to rejuvenate the land. However, over time, providing food security to an ever-increasing population has shortened the *Jhum* cycle drastically to 5-6 years or even less, which is not enough for the regeneration of the land and is unable to enrich the soil with sufficient nutrients naturally. Reducing the *Jhum* cycle length negatively affects the ecosystem, resulting in decreased crop yields and food insecurity. Owing to population pressure and limited land resources, agricultural practices in difficult terrain have shifted from long fallow periods of 10-15 years to shorter cycles of 2-3 years. The soil and water conservation measures constructed in previous *Jhum* cultivation period is damaged due to shorter *Jhum* cycles while preparing field for *Jhum* cultivation. The frequent disturbance due to the short fallow cycle significantly diminishes *Jhum's* ability to regenerate, leading to the loss of valuable fertile soils through run-off and leaching, making the land unsuitable for agriculture⁹⁻¹¹. In Arunachal Pradesh, the current *Jhum* land area has declined by 6.24%, from 1025.07 km² to 961.04 sq. km¹². The estimated soil loss rate under *Jhum* cultivation ranges from 30 to 170 t/ha per year¹³. The locals' best attempts to stop it are not enough, as mountain watersheds are either degrading or at risk of doing so¹⁴. High soil erosion caused by shifting cultivated areas has significantly affected the downstream area, threatening the reservoir capacity, agricultural land, and drainage channels.

Indigenous knowledge, developed over thousands of years in various sectors, is crucial for the overall socioeconomic development of humans. Connecting traditional knowledge systems with scientific advancements can improve the efficiency of existing systems. Although indigenous knowledge systems may seem straight forward to outsiders, they serve as safeguards for the local population's subsistence. Their

attention is frequently focused on the number, quality, and demands of the local population¹⁵. The practices of hill farmers to manage their natural resources, such as preventing and repairing land slip, have been examined through research¹⁶. Therefore, this study aimed to document and analyse the traditional agricultural, soil, and water conservation practices employed by *Galo* tribal farmers across various elevation zones in Arunachal Pradesh. Additionally, the study aims to assess the relevance and effectiveness of these indigenous practices in enhancing productivity and natural resource management and to generate insights for developing region-specific policies that can support and benefit farmers in Arunachal Pradesh.

Methodology

Study area

The study area spanned 754 km² in the Leparada district of Arunachal Pradesh, lying between 27°46'26.4" N to 28°03'43.2" N latitudes and 94°29'05" to 94°55'30" E longitudes (Fig. 1). The altitude in this region varies between 172 and 1886 m above sea level. The district comprises four administrative circles: Basar, Tirbin, Daring, and Sago. It lies in the Eastern Himalayan Ecozone-II, which includes the Alpine and Temperate Sub-Alpine zones. The annual rainfall averages 2466 mm across 142 rainy days¹⁷. During the southwest monsoon, the average maximum temperature is between 27°C and 29°C, whereas the average minimum temperature during winter fluctuates between 5°C and 9°C¹⁸. According to the 2011 census, the population of Leparada district was 14,490, with Scheduled Tribes constituting 11,235 (77.54%) of the total population. The district is predominantly inhabited by the *Galo* tribe.

Data collection

This research relied on data gathered through a combination of methods, including questionnaire surveys, field observations, group discussions, and key informant interviews, to investigate the role of various management practices in soil and water conservation (SWC) and agricultural production within the study area during 2022-2023. As elevation shifts, agricultural methods and conservation strategies are adapted accordingly. The study area was categorized into three elevation zones: low (172-718 m), mid (719-1094 m), and high (1095-1886 m), with agricultural activities predominantly occurring between 400 and 1886 m. Stratified random sampling

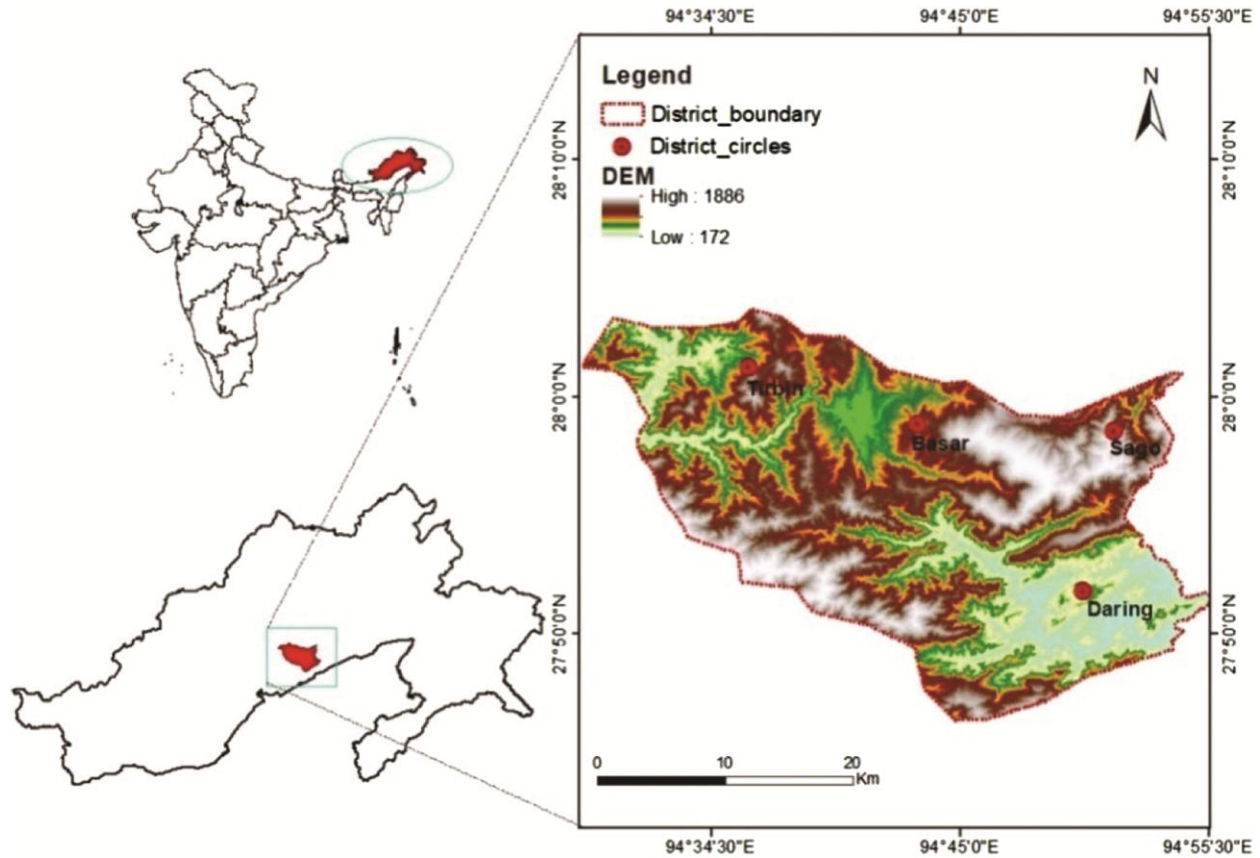


Fig. 1 — Study area (Leparada district) in the hilly Northeastern states of Arunachal Pradesh, India
(Source: <https://bhuvan.nrsc.gov.in/home/index.php>)

was employed, selecting 50 households from each elevation zone, for a total of 150 households. Structured questionnaires were administered, focusing on traditional SWC methods, agricultural practices, and socioeconomic aspects. The survey and conversation response rates with households in all zones averaged 80%. Respondents, typically aged between 60 and 70 years, were selected for their traditional knowledge and were asked about household socio-economic status, landholding, farming practices, crop preferences, perceptions of soil erosion, conservation measures, and indigenous techniques for SWC for their traditional knowledge. Each questionnaire required approximately 30-40 min to complete.

To improve the scientific value, a more detailed analysis was conducted to interpret the comparative effectiveness of traditional soil and water conservation (SWC) methods across various elevation zones in the study area. A one-way analysis of variance (ANOVA) was employed to determine whether there were statistically significant differences

in the effectiveness of these methods among the different elevation zones in the study area. The analysis was performed using R studio, a platform for statistical computing and graphics, with all tests conducted at a 5% significance level ($p < 0.05$) to ensure the reliability of the results.

Results and Discussion

Esiarik (Wet land rice cultivation)

Paddy cultivation is of significant importance in Arunachal Pradesh, covering approximately 0.13 million hectares and yielding around 0.23 million tons of paddy, with an average productivity of 1814.8 kg/ha (2014-2019)¹⁹. The effective implementation of this farming practice can be observed in various parts of the state, such as Tirap, Leparada, and the lower Subansiri district. Wetland rice cultivation, known locally as *Esiarik*, is highly prevalent in the Leparada district. The rice variety grown under these wetland conditions is referred to as *Mipun*. Terraced cultivation on hillsides (Fig. 2a), especially in areas

with soil that retains water well, has been practiced for centuries, even on steep gradients exceeding 100%. These terraces are meticulously constructed with shoulder bunds (Pabey) to retain water and maintain a water depth of 8-12 cm. The height and horizontal spacing of terrace bund are similar in all elevation zones. Paddy farming requires a well-planned network of water channels at the upper ridge of streams to maintain appropriate water levels. Paddy transplanting normally begins in June, and harvesting occurs between the last week of October and mid-November, with a total duration of 120 to 130 days. Soil erosion associated with rice cultivation on sloped terrain in the Eastern Himalayas has been documented to reach levels as high as 32-45 t/ha/year²⁰. 70% of the respondents employed the *Esiarik* method alongside bunds on their fields (Table 1).

Contour farming

Contour farming, also known as eco-friendly farming, is implemented on sloping land to reduce soil erosion caused by water runoff. This method

involves growing crops perpendicular to the slope rather than parallel to it²¹. Contour farming reduces slope length, which reduces runoff water flow speed; therefore, it is especially beneficial on long, gradual slopes, where flow velocity tends to be higher. The best results were obtained from contour farming on slopes between 2% and 10%. According to the survey results, approximately 68.33% of the respondents use contour farming in their fields, which is a commonly used method for conserving water and soil (Table 1). All agricultural operations, including intercultural cultivation and ploughing, are carried out along the contour line (Fig. 2b). Maize, yam, tapioca, ginger, turmeric, colocasia, and sweet potato are grown using contour farming. Farmers report a 10-15% increase in crop yield and a 50% decrease in soil erosion on contour farming land²².

Mixed cropping-based production system

Farmers practicing shifting agriculture usually cultivate 8-35 crop species within a 2-2.5ha area by sowing and harvesting in sequence. The crop mixture

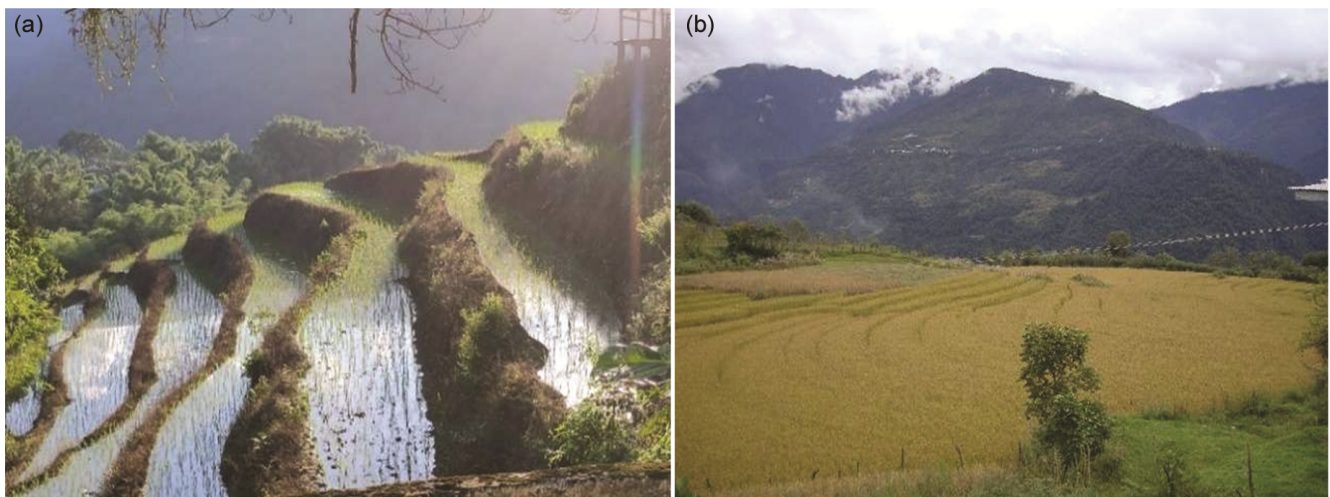


Fig. 2 — (a) Wetland rice terrace cultivation, (b) Cultivation along the contours at Basar circle, Leperada district of Arunachal Pradesh

Table 1 — Indigenous soil and water conservation practices in the Leperada district of Arunachal Pradesh

Agricultural/management Practices	Elevation Zones			Mean %
	Low (n=50) (%)	Mid (n=50) (%)	High (n=50) (%)	
<i>Esiarik</i> (Wet land rice cultivation)	70	70	70	70
Contour Farming	60	70	75	68.33
Mixed Cropping-based Production System	82	91	94	89
Mulching	80	75	70	75
Vegetative barriers	70	80	90	80
Water harvesting ponds	70	77	60	69
'Kombo' the traditional bamboo channel system	60	50	40	50
'Paper' the traditional soil conservation system	30	70	80	60
Agroforestry	65	70	75	70

enhances soil properties, maximizes resources, permits the recycling of nutrients and biomass, and protects crops from nutrient losses. In Arunachal Pradesh, mixed crops are cultivated in *Jhum* regions, where the major crop is rice (Bali-upland rice). *Jhum* farmers grow diverse crops, including cereals, legumes, oilseeds, fruits, cash crops, and spices (Table 2, Fig. 3a-3i). Approximately 89% of farmers adopt mixed cropping

systems, mostly on *Jhum* land, to ensure that at least one crop is yielded and to diversify production. In this mixed cropping system, crops use different nutrients from different depths, so there is maximum use of available nutrients from the soil. This system ensures complete nutritional security for the farmers.

Mulching

The application of organic or inorganic materials to soil surfaces is known as mulching, and it aims to retain moisture, suppress weeds, regulate temperature, and improve soil²³. Tribes apply stubble, trash, and other chopped grass from the field or bounds to the surfaces to reduce the threat of weeds while minimizing erosion and preserving *in-situ* soil moisture. Most farmers reported using mulch in their fields because they understood the advantages of using protective coverings. Arunachal Pradesh is renowned for the *Toko* tree (*Livistona Jenkinsiana Griff*), prompting farmers to utilize its dry leaves, locally known as *Toko patta* (tayek), as mulch for

Table 2 — Major crops cultivated by *Jhum* farmers in shifting cultivation systems

Crop type	Examples
Cereals	Rice, Maize, Millets
Root crops	Cassava, Yam, Colocasia, Sweet Potato, Potato
Legumes	Beans, Pigeon Pea, Soybean, Cow Pea, Rice Bean
Oilseeds	Mustard, Groundnut
Cucurbits	Pumpkin, Bottle Gourd, Cucumber, Bitter Gourd, Melons, Snake Gourd, Ridge Gourd
Vegetables	Tomato, Brinjal, Chili, French Bean
Fruits	Pineapple, Papaya, Banana, Mandarin
Cash crops	Areca Nut, Coffee
Spices	Large Cardamom, Cardamom, Black Pepper

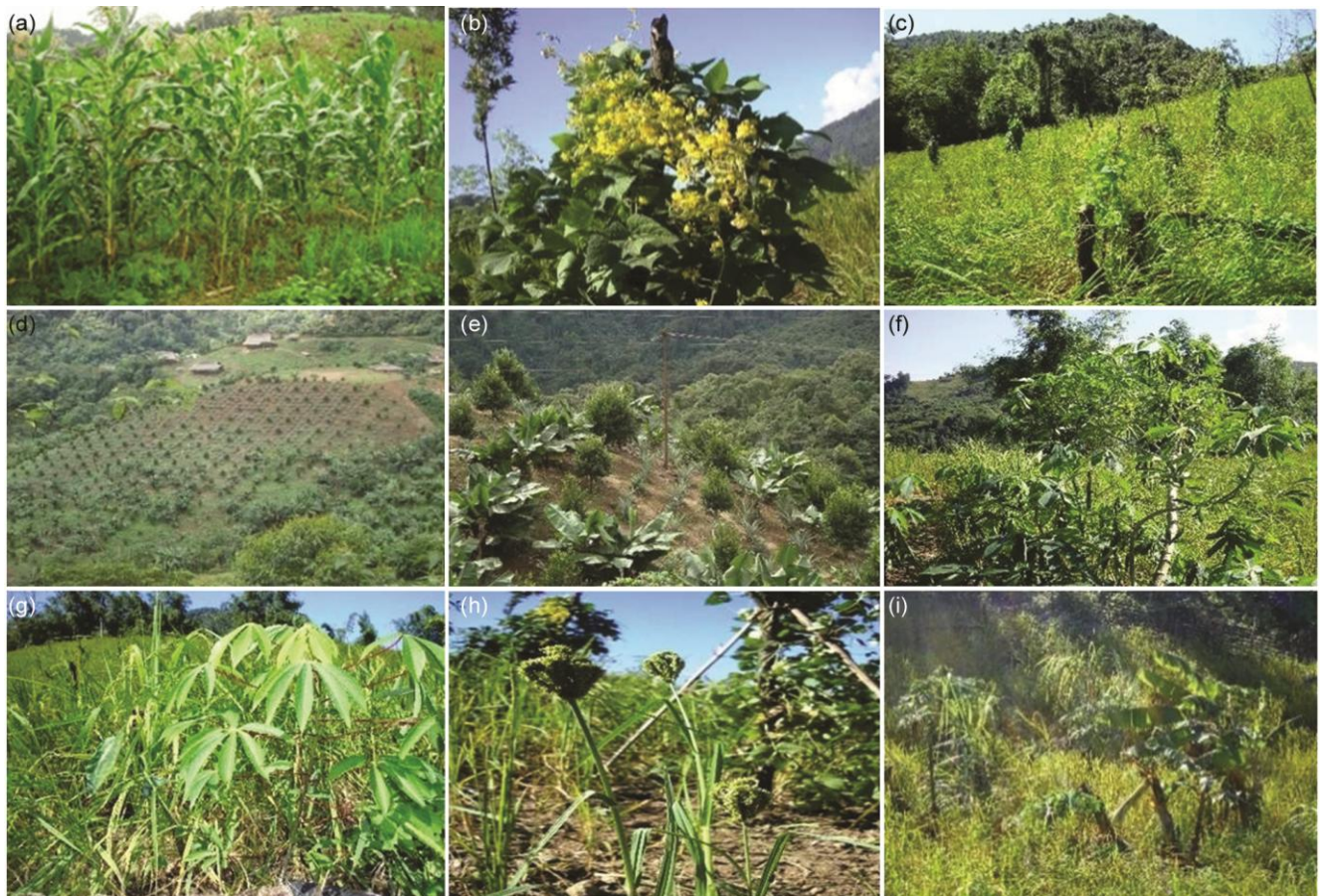


Fig. 3 — Traditional mix cultivation on *Jhum* land - (a) rice + maize; (b) rice + rice bean; (c) rice + dioscorea; (d & e) pineapple + khasimanderin + banana; (f) rice + tapioca; (g) rice +cassava; (h) rice + finger millet; (i) rice + papaya + banana

various fruit plants like banana, mandarin, papaya, and pineapple (Fig. 4a). The use of these leaves is not limited to crafting homes (namey), grain storage structures, *abongs* (rain protection covers), and local baskets. Communities with traditional backgrounds, such as the *Adi*, *Galo*, *Nyshi*, and *Mishing* in Arunachal Pradesh, have historically relied on this valuable resource. Mulching was used by approximately 75% of the farmers in the study area. In addition, rice crop residue is spread across fields during the winter months of December and January to

serve as mulch for vegetative crops, which reduces irrigation requirements by 30% (Fig. 4b). Importantly, no significant differences were observed among the three elevation zones regarding the proportion of farmers who engaged in mulching practices (Table 3).

Vegetative barriers

To prevent erosion, control sediment, and stabilize slopes on sloped lands, a vegetative barrier can be natural or planted and includes grasses, shrubs, trees, and cover crops with roots that bind the soil (Fig. 4c).



Fig. 4 — (a) *Toko patta* mulch on pineapple plantations; (b) Rice straw mulch on vegetable crop; (c) Sweet potato (covering crop); (d) *Flemingia*, (Green manure crop) at border of the terrace; (e) Jalkund; (f) Water harvesting pond at foothill of the slope; (g) Indigenous bamboo channel; (h) Connection point of two sections of bamboo channel

Table 3 — Variance analysis results for traditional soil and water conservation methods across different elevation zones in the Leparada district of Arunachal Pradesh

Elevation Zones	Mean	Std. Dev.	F-test (Calculated)	F-test (Tabulated)	Significance Level	Result (p<0.05)
Low	65.2	15.3				
Mid	72.6	10.9	0.805	3.40	0.05 or 5%	No significant variation
High	72.7	16.1				

A one-way ANOVA conducted at a significance level of $p < 0.05$ indicates that there is no statistically significant difference among indigenous SWC practices across the three elevation zones.

Contour planting and cultivation are the primary agricultural techniques used by the tribes in Leparada to conserve water and soil. Their effectiveness does not require any significant financial investment. Fodder trees are frequently planted along bunds and field boundaries like *Schima wallichii* (Chilaunay), *Ficus nemoralis* Wall (Dudhilo), *Melia azedarach* L. (Bakaino), *Ficus roxburghii* Wall (Nebara), *Artocarpus lakoocha* (Badahar), *Ficus nemoralis* (Khaneu), *Engelhardtia spicata* (Mahua), and *F. clavata* (Khaneulutey). Green manure crops such as *F. macrophylla* (Flemingia), *Tephrosia purpurea* (Sharapunkha), and *C. ochroleuca* G. Don. (Crotalaria) serves multiple purposes, such as effective erosion control, providing shade or shelter, enhancing soil quality, and serving as windbreaks (Fig. 4d). Apart from beans and pulses, fruit trees such as papaya and orange and natural grasses such as *Thysanolaena maxima* (Amlisho) and *Pennisetum agrostis* (Napier) are cultivated. Planting *Amlisho* with a horizontal spacing of 4.5 to 6.0 m benefits the landscape by aiding in moisture retention and stabilisation, while also proving economically advantageous²⁴. A healthy single *Amlisho* plant produces approximately 3-4 kg of flowers annually, which, at a market value of Rs. 30 per kg, equates to an income of Rs. 90-120 per plant for farmers. This versatile approach has been widely adopted throughout the district.

Water harvesting structures

In Arunachal Pradesh, monsoon rains from June to October account for the heaviest precipitation. The typical rainfall is 2500 mm²⁵. This intense rainfall caused more runoff. Locally constructed structures have been used to conserve runoff water. These structures, which are available in different sizes and can either have linings or not depending on the catchment area and farmers' needs, are designed to enhance rainwater storage in watersheds. Their objective was to increase the availability of water during dry spells. Some interventions for water harvesting include farm ponds, dugout ponds, lined ponds, and jalkunds (Fig. 4e). Jalkunds, small water harvesting structures, are situated on hilltops or in the middle of slopes, whereas farm ponds are located in the lower areas of farms, serving multiple functions (Fig. 4f). Irrigation for the land above is achieved by pumping water from these ponds, whereas the land below is irrigated through gravitational flow. Water harvesting ponds were used by 69% of farmers in the study area for irrigation purposes. Jalkund are

predominantly located in the Basar, Pagi, Gori, and Lipunamchi villages within the Leparada district. These ponds usually have dimensions of 6m by 4m and a depth of 1.5m. The water harvested from these ponds is effectively used to irrigate various crops, including maize, soybean, mustard, cabbage, chili, pea, tomato, and potato. In the Basar circle of the study area, notable percentage increases in crop yields were observed: 27% for maize, 25.5% for soybean, 25.7% for pea, 25.5% for mustard, and 38% for chili using harvested water²⁶.

'Kombo' the traditional bamboo channel irrigation system

Bamboo is abundantly present in the Arunachal Pradesh state, and it is a crucial resource for transporting irrigation water in the region. Spring water that originating from sub-surface flows and streams coursing through mountainous terrain is used to capture water by utilizing the natural landscape. Mountain streams are especially important for irrigating paddy fields during dry spells in the monsoon. To facilitate the conveyance of water, Hamilton's bamboo (*Dendrocalamus hamiltonii*), locally called 'Eni', available in various sizes, is ingeniously employed as a channel (Fig. 4g). This traditional technique is incredibly economical compared to more recent options, such as the use of PVC pipes. This water conveyance system is referred to as 'Kombo' by the local tribes. Using a regionally available axe known as 'Orok', bamboo channels are built locally by the villagers. Bamboo channels can last up to a year or longer, with a length of 10-15 m (Fig. 4h), a diameter of 10-12 cm, and a flow rate of approximately 0.2 L/s (without rain), sufficient for one field. For optimal efficiency, bamboo channels are updated annually. The length of the channel varied from 5-10 km. Approximately 50% of the respondents had participated in the bamboo channel irrigation system, and there were no notable differences in the percentage of farmers who had constructed them across the various elevation zones (Table 3).

'Paper' the traditional soil conservation system

Paper, a traditional soil conservation technique in Arunachal Pradesh, involves the strategic placement of bamboo or wood logs in *Jhum* fields across the slopes (Fig. 5a). This process lasts 3-5 years creates barriers on steep slopes to prevent soil erosion and retain soil moisture. The wooden logs typically measure 3-4 m in length (Fig. 5b) and 8-12 cm in diameter, with horizontal spacing between them ranging from 4-6 m.

Paper plays a crucial role in managing runoff water and preventing soil erosion by intercepting water flow down the slope, thereby reducing erosion and sedimentation downstream in *Jhum* fields. These barriers also aid in retaining soil moisture, promote healthy plant growth, and enhance soil fertility. The *Galo* tribes (Fig. 5c) utilize *Paper* as an efficient and sustainable approach to soil conservation, utilizing locally available materials and indigenous knowledge to mitigate erosion effects and preserve soil quality. This practice is increasing as farmers find it cost-effective, environmentally friendly, and well suited to local terrain and resources. The survey results indicated that almost 60% of the participants used *Paper* in their *Jhum* fields. *Paper* is a commonly used soil and water conservation (SWC) technique in the region, mostly because of its visual impact as a sediment trap. The effectiveness of the *Paper* system in controlling soil erosion indicates that it can retain approximately 160 tons per hectare per year²⁷ (Fig. 5d).

Traditional Agroforestry interventions for soil conservation

Agroforestry has long been recognized for its ability to enhance agricultural productivity while simultaneously conserving and improving soil fertility.

It involves strategically integrating trees or woody perennials into crops to benefit from the resulting ecological and economic synergies. In the Sago circle of the Leparada district, agri-silviculture is practiced by retaining *Terminalia myriocarpa* (Hollock) and *Morus laevigata* (Bola) within *Jhum* fields and planting them along the periphery. Similarly, in the Tirbin circle, agri-silvi-pastoral systems involve cultivating *Broom grass* (*Thysanolaena maxima*) along the margins of cropland terraces, which prevents soil erosion and also is used in making brooms (Fig. 6a). In horti-silviculture, a variety of fruit trees like orange, pineapple, and banana are planted alongside and forest trees such as *Dipterocarpus* sp. (Gurjan), *Albizia lebeck* (Siris), *Macaranga denticulate* (Blume), *Schima wallichii* (Needlewood), and *Acacia* spp. These trees provide fuel, timber, and fodder enhance the soil through nitrogen fixation. Silvi-pastoral practices involve the integration of tree groves and bamboo stands within pastures. Common bamboo species include *Melocanna bambusoides*, *Dendrocalamus hamiltonii* (Hamilton's bamboo), *Arundinaria callosa* (Munro), and *Arundinaria gigantea* (Canebreak Bamboo), whereas common grasses such as *Cynodon dactylon* (Bermuda grass), *Panicum maximum* (Guinea grass) (Fig. 6b),



Fig. 5 — Indigenous shifting cultivation areas showing (a) '*Paper*' the conventional farming method of soil conservation; (b) Measurement of length and width of the wooden logs; (c) traditional way of paddy sowing; (d) Soil preservation through the use of wooden logs

Imperata cylindrica (Cogongrass or kunai grass), *Thysanolaena maxima* (Broom grass), *Chrysopogon* spp., *Paspalum* spp., and *Setaria* spp. provide ground cover to protect against soil erosion. Farmers favour *Thysanolaena maxima* (broom grass), fruit trees like orange, banana, and pineapple, and *Morus laevigata* for income. Bamboo species, *Cynodon dactylon*, and

Panicum maximum are preferred for soil conservation and erosion control.

The knowledge of ITK used in the study area is passed down from one generation to the next by practical application in the field. The scientific significance of each activity in Arunachal Pradesh's agricultural ecosystem is presented in Table 4.

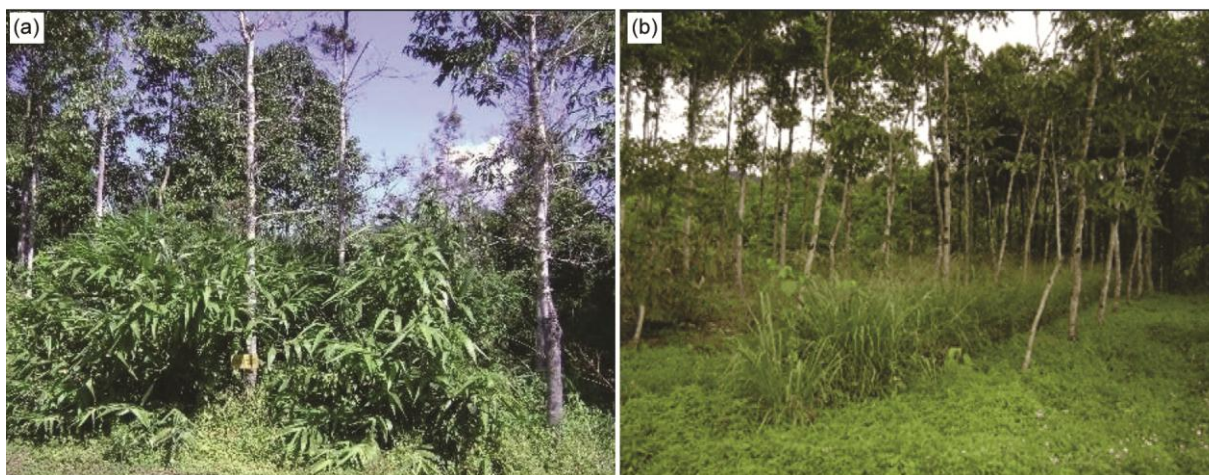


Fig. 6 — (a) Cultivation of Broom grass (*Thysanolaena maxima*); (b) Guinea grass (*Panicum maximum*) in Silvipastoral system

Table 4 — Indigenous technical knowledge (ITK) practices employed by farmers in Arunachal Pradesh and their scientific relevance in the context of sustainable land and water management

Agricultural/management Practices	Scientific importance of the existing ITK
<i>Esiarik</i> (Wet land rice cultivation)	This approach allows for regulated water levels, which reduces water waste, improves irrigation efficiency, and maintains a uniform depth of water in the field. It also encourages water conservation by limiting runoff and soil erosion using the earthen bunds. Wetland rice fields operate as carbon sinks, absorbing CO ₂ from the atmosphere and storing it in soil. This can help mitigate climate change by reducing greenhouse gas emissions.
Contour farming	Contour farming respects the inherent contours of the slope, thereby refraining from altering its natural shape. This strategy adeptly absorbs the force of heavy rainfall, unlike conventional straight-line planting methods, which often result in the erosion of valuable topsoil.
Mixed cropping-based production system	Mixed cropping is a common practice in <i>Jhum</i> cultivation areas, where different crops are cultivated with varying rooting depths, growth periods, and nutrient and water requirements. This system allows different crops to extract nutrients from different soil depths, enrich soil quality, and mitigate drought effects, providing farmers with both nutritional and food security benefits.
Mulching	<i>Toko</i> trees are abundant in the study region and are extensively used by local farmers for mulching due to their cost-effectiveness. This practice serves the dual purpose of retaining soil moisture and protecting the soil from erosive effects of heavy rainfall.
Vegetative barriers	Some vegetative barriers serve many functions, including efficient erosion control measures and windbreaks, which help prevent wind erosion of soil particles and reduce the risk of crop loss from strong winds.
Water harvesting ponds	Jalkunds help store rainwater, which may subsequently be used for irrigate during dry spells. This practice conserves water resources and decreases dependence on groundwater and surface water sources, especially in mountainous regions where surface water availability is limited.
'Kombo' the traditional bamboo irrigation channel system	Bamboo is readily accessible in the region and can be installed with minimal expenses. The use of bamboo for irrigation channels eliminates seepage losses, thereby enhancing the conveyance efficiency. This allows for the irrigation of a larger area using the same amount of water.
'Paper' the traditional soil conservation system	<i>Paper</i> , a soil-stabilizing material, is resistant to flash floods and helps to capture soil particles. It decomposes, enriching the soil with nutrients from wood logs or bamboo, making them environmentally friendly and sustainable, and reducing the need for replacement.
Agroforestry	Bamboo plantations in <i>Jhum</i> areas contribute to soil preservation by anchoring soil particles with their strong root system, absorbing surplus water during rainy seasons, and gradually releasing it during dry periods, benefiting nearby crops. In addition, bamboo plays a vital role in capturing carbon dioxide from the atmosphere, particularly during subsequent <i>Jhum</i> burning seasons. In horti-silvi-culture, these forest trees offer fuel, timber, and fodder, while enriching the soil through nitrogen fixation.

Conclusion

In the hilly terrain of Arunachal Pradesh in the Himalayan region, where rainfall is abundant during the monsoon, soil erosion is a significant socio-environmental challenge. This erosion mainly affects *Jhum*-cultivated areas due to concentrated rainfall and terrain characteristics. Although conventional agronomic and vegetative measures have shown limited effectiveness, the region harbours a wealth of indigenous knowledge on soil and water conservation. However, these traditional methods often require labour-intensive approaches and are not easily mechanized because of the challenging terrain. Undulating topography complicates mechanization efforts, increases costs and potentially worsens erosion. Despite these challenges, the area boasts a strong tradition of employing indigenous practices for soil and water conservation, including wet land rice cultivation, contour farming, agroforestry, vegetative barriers, bamboo irrigation channels (*Kombo*), mulching, mixed cropping, water harvesting ponds, and traditional soil conservation system (*Paper*). These indigenous wisdom-based practices are unrestricted and easily accessible to the public. For sustainable land management, it is imperative that this traditional knowledge be conserved and transmitted to future generations. To achieve sustainable land management in high-rainfall areas prone to soil erosion, state-level policy frameworks must incorporate regional soil and water conservation methods into watershed management initiatives. Promoting traditional systems such as *Kombo* for efficient irrigation and integrating *Paper* with modern erosion barriers would further enhance the relevance and effectiveness of these efforts in the future. Supporting marginal farmers should be a top priority for policy initiatives because they are essential for the land sustainability of the region. One more thing is that all the traditional knowledge is environmentally friendly and make use of locally available material. The study is limited by the possibility of recall bias among older participants and the limited applicability of its results to other regions due to the unique features of the study area's hilly and sensitive ecosystem. Local governance mechanisms and agricultural extension services must actively involve local representatives in decision-making processes. This approach will aid in prioritizing areas that are most at risk of erosion and encourage the implementation of sustainable agricultural practices along with indigenous methods for soil and water conservation.

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Conflict of Interests

The authors have declared no conflicts of interest.

Author Contributions

AS: Investigation, data collection, writing; DS: Review, and editing; AT: Data collection, RS: Data collection, Review; RAA: Data collection; TA: Editing, LW: Review; BUC: Review, and editing; AKN: Review.

Prior Informed Consent

The key informants (tribal householders) were informed in advance about the purpose of the study, and they voluntarily provided their consent for sharing traditional knowledge and permitting photography.

Data Availability

The authors confirm that the data supporting the findings of this study are available within the article.

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