ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul510

Reviewing the Role of Technological Advancements in Enhancing Indigenous Soil Conservation Practices: Special Reference in Kodaikanal Region

Dr. K. Kavitha*

Assistant Professor, Department of Computer Science,
Mother Teresa Women's University, Kodaikanal.
Tamilnadu, India

Publication Date: 2025/07/15

Abstract: Due to the change in land-use practices, deforestation, and climate unexpectedness, soil erosion is becoming more threatened to the tribal mountainous areas of Kodaikanal. Although indigenous groups have long used traditional soil conservation techniques, these approaches have not officially recognized and are not very effective in front of contemporary environmental stresses. Recent years have seen the ability of technical successes to change the ability to completely replace durable agriculture and soil management techniques, especially in the Internet of Things (IOT), Artificial Intelligence (AI), and the areas of the Geographical Information System (GIS). However, there is still a lot about how to combine this technique with traditional knowledge systems for Kodaikanal soil conservation. This review study assesses the suitability of digital technology for soil conservation in relation to indigenous practices by seriously analyzing national and international literature.

The study exposes gaps in previous researches and suggests a hybrid framework that combines data-operated innovations with traditional ecological knowledge, especially in steep tribal areas such as Kodaikanal where there are no recorded technology-acquired soil models. Application of generic AI for landscape-based land-use consultant and erosion modeling, the manufacture of bilingual mobile platforms for farmer outreach, and potential use of real-time IOT sensors enabling soil health monitoring is examined. By doing this, the report provides a route for the upcoming multidisciplinary initiatives that prefer stability, inclusion and community participation. In addition to providing scalable insight to other ecological delicate and culturally rich places, it emphasizes the need to preserve and improve traditional methods through reference-inconceivable technical support. With the goal of focusing from erosion to ecological flexibility, this work performs the ground task to develop the first-time implementation strategy in the Kodaikanal region.

Keywords: *Indigenous Knowledge Systems, Soil Conservation, Technological Integration, Kodaikanal Hills, Tribal Farming Practices, Rural Technology Adoption.*

How to Cite: Dr. K. Kavitha (2025) Reviewing the Role of Technological Advancements in Enhancing Indigenous Soil Conservation Practices: Special Reference in Kodaikanal Region. *International Journal of Innovative Science and Research Technology*, 10(7), 606-609. https://doi.org/10.38124/ijisrt/25jul510

I. INTRODUCTION

One of the most important environmental issues affecting biodiversity, agricultural stability and rural livelihood is soil erosion, especially in steep and ecological delicate areas. The decline of land brought by irregular rainfall, deforestation, uncontrolled tourism, and shifting land-use patterns is a growing threat to the tribal dominated highlights of Kodaikanal, which are located in the Western Ghats of Tamil Nadu. Methods of subsistence cultivation used by indigenous groups, which rely on these areas for food and cultural identity, are also negatively affected by these environmental changes, which also disturb the ecological balance.

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Tribal inhabitants of Kodaikanal l have for a long time relying on the wealth of traditional ecological knowledge (TEK) to preserve their soil. Their methods, including mixed cultivation, are based on the years of mulching, contour bunding, and stone terracing, environmental leadership and observation years. However, climate is trying to try these and true techniques in the mainstream agricultural science, ownership of shrinking land, and official verification in mainstream agricultural science. In addition, indigenous protection knowledge is gradually disappearing due to lack of systems to migrate and transmit knowledge of younger generations. On the other hand, agricultural technology has become quite advanced in the last ten years, especially with the use of Geographical Information System (GIS), Artificial Intelligence (AI), and Internet of Things (IOT) equipment. By facilitating the real-time monitoring of soil parameters, producing crop and land management forecasting insights, and increasing decision making through data-operated interventions, these devices have revolutionized accurate agriculture. Even with their widespread popularity, these technologies are still mostly unavailable and unwilling to the tribal mountainous regions of India, such as Kodaikanal.

To create a hybrid, scalable paradigm for permanent land management, this review paper checks how state-of-the-art digital technology can be effectively combined with traditional soil conservation techniques. The report conducted a thorough investigation of national and international research on the application of AI, IOT and GIS for soil conservation and monitoring. The compatibility of these innovations with traditional knowledge systems is then seriously examined, which emphasizes environmental suitability, community participation and cultural sensitivity.

This research uses a new, multi-disciplinary structure as a case study as a case study that integrates mobile-based advisors designed for rural users, predicting AI-operated erosion and collecting land-use suggestions and real-time data (through IOT sensors). The importance of the tribal sounds being included in the implementation of co-design and such systems, as well as participation, is emphasized in the article, on the value of rural assessment. In the end, this study emphasizes how we should transition from traditional, traditional erosion management strategies for an inclusive, technically promoted conservation paradigm - a one who respects traditional knowledge using the ability to digital innovation. By doing this, it provides a basis for reproducible models in other tribal and mountainous regions that are at risk and comparable ecological and sociological issues.

II. LITERATURE REVIEW: SOIL CONSERVATION AND ENVIRONMENTAL KNOWLEDGE IN KODAIKANAL HILLS

A. Soil Erosion and Land Degradation in Kodaikanal

Forest harvesting, uncontrolled tourism, agricultural development, and changing land-use patterns are all factors in growing soil erosion in the Kodikanal hills, which are a part of the Western Ghats. Studies employed by Geographical Information System (GIS) and remote sensing (RS) have detected Stark shifts in forest cover and vegetation, which increase the risk of landslides and soil down. In a morphological study in the Kodikal region, Bagyaraj and Guruganam (2011) found that drainage patterns had a major impact on areas that were prone to erosion [1]. Uma Maheswari et al, using multi-temporal satellite imagery. (2015) verified the swift conversion of the natural landscape in the built-up zone and further verifying the loss of about 10% of the forest cover between 2006 and 2011 [2].

B. Landslide Risk and Slope Stability

When Sivakami and Rajkumar (2020) mapped landslide danger in the Kodaikanal Taluk using a Weights-of-Evidence GIS model, they found that areas with steep slopes and intense rainfall are the weakest [3]. Especially in tribal agricultural areas which depend on terraced or slop-based agriculture, the study of this type of area is directly related to soil stability and protection.

C. Indigenous Agricultural Practices

Oral traditions and dynastic sources indicate that tribes such as Paliyar and Puliyan uses contour bunding, agroforestry, mulching and natural fertilizers, despite the lack of formal research on traditional knowledge systems of tribal population in Kodikanal. Despite corresponding to regional ecological conditions, these methods are still inaccessible in most of the colleagues reviewing agricultural or soil scientific publications. The importance of incorporating traditional ecological knowledge (TEK) through formal protection and development schemes has been lined by Berkes (2000)[4] and Mazzocchi (2006) [5]; Nevertheless, in this integration, there is a decrease in soil conservation literature currently Kodaikanal.

D. Technology in Soil Monitoring: Missing in Kodaikanal

There is no notable soil health monitoring initiative in Kodaikanal that uses sensor technologies or AI-based erosion models despite the ability of IOT and AI in agriculture. Although accurate agricultural equipment has been used in other parts of India, they still have very little use in hilly tribal areas. Additionally, the hill tribes have a lack of bilingual resources or indigenous mobile advisory platforms.

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E. Watershed Management and Conservation Programs

The Ministry of Environment, Forest and Climate Change along with the Tamil Nadu Forest Department has developed several watershed management and forest conservation initiatives [6]. However, initiatives do not include tribal farming practices or soil conservation techniques; instead focus on biodiversity and forest restoration around Berijam Lake and Shola Woods.

III. IDNETIFIED GAPS

In the Kodaikanal region, there is a glaring gap between traditional soil conservation methods and contemporary digital interventions, even with traditional ecological knowledge and abundance of current development in agricultural technologies. Table 1 lists the main gap found by literature review and early field observations.

Table 1. Lists the Main Gaps Found by the Literature Review and Early Field Observations.

Gap Area	Description
Lack of Real-Time Soil Monitoring	There is no IOT-based sensor deployment to the tribal fields in Kodaikanal to monitor soil factors such as temperature, pH, moisture content and sloping fluctuations.
Absence of Technology-Enabled Advisory Systems	Tribal hill houses have yet to see the introduction or adaptation of AI or machine learning-based future-based devices for soil erosion, rainy modeling, or adaptive crop techniques.
Disconnection Between Traditional and Scientific Knowledge	The lack of scientific verification of indigenous methods such as official research, digitization, or contour bunding and holy grove conservation results in their underutilization in the contemporary conservation scheme.
Language and Accessibility Barriers	Tribal farmers with low internet connectivity or literacy cannot use the majority of contemporary digital advisory tool as Offline-capable mobile dashboards or apps available in Tamil are not available.
Minimal Community Participation in Tech Design	Most of the current conservation and technical initiative of the region are top-downs, with slight inputs from local stakeholders-especially in the plan or implementation of tribal youth or elderly-interference.
Lack of Integrated Databases or GIS Layers	To advise site-specific tasks, there is no centralized GIS database that superimposes environmental risk areas, slope gradients or watershed data at the top of traditional soil knowledge.
No Scalable Pilot Studies	The Kodaikanal Hills have not yet been used as a testbed for hybrid models, unlike other areas of India, combine AI, IOT and community-operated techniques, where digital agricultural pilot initiatives have started.

IV. PROPOSED FRAMEWORK

The following elements are suggested to improve indigenous soil practices and stop digital differences.

- *Internet of Things Soil Monitoring Units:*

Solar-operated, low-power sensors that measure frequent temperature, pH, moisture content and slope variation.

- *Generic AI Modeling:*

This technique simulates future erosion conditions and recommends adaptive farming practices using data from many seasons.

- *GIS-Based Mapping:*

Traditional protection sector and high-risk erosion sector are mapped by the community.

- *Bilingual Dashboard:*

Easily used smartphone interfaces in Tamil and English that provide initial warnings, AI-related recommendations and updates on soil health.

- *Community Training:*

Young people in the area will receive training as facilities for using, understanding and sharing technology discoveries in the community.

V. DISCUSSION

Through relevant technology adaptation, the hybrid method modernizes indigenous history by maintaining its honor. This concept prioritizes co-construction over applying external systems; the community reaction informs the AI algorithm with the driving system design and tribal knowledge. This participation approach guarantees high adoption and cultural fit. Additionally, using real -time monitoring and climate data can help communities prepare for climate tremors such as unexpected drought or flash floods.

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VI. CONCLUSION

Soil conservation of Kodaikanal Hills depends on the future new digital technologies to balance traditional knowledge. This review suggests that when the area does not have a previous integrated approach, effective models from other places can provide scalable solutions when adapted to ecological and cultural realities. For indigenous communities of the region, a technology-capable, community-focused soil management system can guarantee long-term stability, increase in crop yields, as well as cultural continuity.

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