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ORIGINAL ARTICLE

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Extent of Awareness, Utility and Constraints in Adoption of Site-Specific Land Resource Inventory Information in New Generation Watersheds

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ABSTRACT

The Land Resource Inventory (LRI), a scientific farm-level planning tool introduced under Karnataka's Sujala-III watershed project, has low field adoption among farmers despite its strengths. This study examines awareness, dissemination, utility, and adoption barriers across 20 micro-watersheds using surveys of 900 farmers and focus groups with Project Implementing Agencies (PIAs). Findings show a steep drop from awareness to actual use, with only 22% of farmers knew about LRI, 20.2% received LRI cards, 11.4% had training, and only 6.56% used LRI information for crop or nutrient decisions. Just 2.89% had read their LRI card more than once, and only 5.89% remembered LRI details of their land. Major LRI adoption constraints include lack of awareness of site-specific information (70%), insufficient training, conservatism and illiteracy among watershed farmers. From the PIAs perspective, key challenges included difficulty in promoting adoption of site-specific crop suitability, securing acceptance of recommendations among farmers, and timing issues with LRI card delivery. Overall, low adoption stems from systemic institutional, logistical, and behavioral gaps, requiring farmer-focused dissemination, stronger extension links, integration of LRI with existing systems, and participatory planning to align scientific advice with local needs.

1 | INTRODUCTION

In the context of climate change, watershed management plays a crucial role in reducing weather-related risks, building resilience, and enhancing adaptive capacities (NABARD, 2023). In regions with low rainfall, watershed management is vital for protecting the environment and maintaining the standard of living (Zerga, 2025). Integrated watershed management has become a climate-smart approach to tackling various agricultural sustainability challenges by improving soil and water conservation (Jayaraman *et al.,* 2024). Effective watershed management requires strengthening institutional capacity, integrated water resources management, strong monitoring, strategic partnerships (Mishra *et al.,* 2024), climate adaptation strategies, economic valuation, and advocacy (Jat *et. al.,* 2025). Additionally, India invests millions of rupees to promote sustainable growth in rainfed areas through effective watershed management programs. However, despite significant investments, many traditional watershed programs in India have not delivered expected outcomes due to lack of site-specific planning, inefficient resource use, and limited farmer awareness (Lalitha *et al.,* 2016; Hegde *et al*., 2018). Several studies highlight the need for comprehensive land resource databases that match site-specific conditions (Bandyopadhyay *et al.*, 2009; Kumar *et al.*, 2014; Ramamurthy *et al*., 2016; Bandyopadhyay *et al.,* 2018; Hegde *et al.,* 2018). As a solution, the Sujala-III watershed project adopted a site-specific and scientifically based Land Resource Inventory (LRI) approach for planning and implementation across multiple districts in Karnataka. This innovative project uses modern Remote Sensing (RS) and GIS data combined with field survey to gather land resource data at the farm level. The project aims to provide farm-specific crop recommendations, develop location-specific soil and water conservation measures, and generate datasets and inputs for planning, implementation, and monitoring of all land-based developmental programs. The LRI database offers information on suitable areas for specific crops, limitations, site-specific nutrient status, and other parameters. It assists Project Implementing Agencies (PIAs) in identifying appropriate, site-specific watershed interventions (Hegde *et al*., 2018; Ravi *et al.*, 2022b). Moreover, the innovative idea in Sujala-III involves distributing LRI cards for individual land survey numbers to farmers and training them to follow LRI recommendations. The LRI card includes details such as the farmer's name, micro-watershed name, sampling year, average rainfall, soil physical properties, land capability class, and limitations. Based on this information, soil nutrient and pH status are described, and the crop suitability class (Highly suitable, Moderately suitable, Slightly suitable, and Unsuitable) with management options is indicated on the card (Ravi *et al.*, 2022b). This approach helps farmers plan scientifically

at the farm level and adjust land use according to crop and soil suitability, optimizing resources, reducing waste, mitigating climate change impacts, and maximizing benefits (Singh *et al*., 2022) and these benefits can only be realized through proper understanding and implementation of LRI recommendations at the field level. Therefore, the study was conducted in LRI-based watersheds to assess awareness, utility, and constraints related to the adoption and implementation of LRI under the Sujala-III watershed project across different districts in Karnataka. This was the first study to investigate the adoption, utility, and constraints of LRI-based watershed management.

2 | MATERIALS AND METHODS

2.1 | Study Watersheds

An impact assessment of the Land Resource Inventory (LRI) watersheds was conducted from 2021 to 2024 to examine LRI information dissemination, adoption, utility, and constraints associated with its adoption and implementation. The average annual rainfall of selected micro-watersheds ranged from 580 to 939 mm, with most watersheds falling in low to medium rainfall regions (Table 1). All watersheds were implemented during 2014-2019 under World Bank-aided Karnataka Watershed Development Programme (KWDP)-II, popularly known as Sujala-III project, with the newly adopted site-specific LRI in watershed planning.

2.2 | Sample Technique

The household survey has been conducted in seven Sujala-III project implemented districts of Karnataka, covering a total of 900 sample households, with 45 households per micro-watershed and 20 micro-watersheds per sub-watershed, using a stratified random sampling technique, as shown in Table 1. Further, seven Focus Group Discussions (FGDs) were conducted with Project implementing Agencies, involving a diverse group of team members, including Assistant Agriculture officers and Watershed Assistants from each micro-watershed across all 7 districts, to understand the constraints and their severity in adoption and implementation of LRI interventions.

2.3 | Statistical Tools and Technique

Descriptive statistics were used to capture LRI awareness, capacity building status and utility of information among farmers. Constraints on various parameters were identified through the household survey, and the frequency of each constraint was presented to highlight the major issues affecting farmers across watersheds. Since the project was the first of its kind and no earlier studies had documented LRI-related constraints, farmers were asked open-ended questions rather than a pre-defined list. This helped to capture a broader range of possible constraints and their severity among the majority of farmers. Meanwhile, the list of implementation constraints was discussed among PIAs, and common constraints were grouped for data collection. Each FGD had 6-12 members, based on availability. For each identified constraint, the group jointly assigned a single severity score based on a five-point Likert scale, where 1 = Very Low, 2 = Low, 3 = Medium, 4 = High, and 5 = Very High, representing how serious the constraint was perceived to be in hindering the implementation of LRI activities at the field level. Further, a simple mean severity score is computed for each constraint to quantify the perceived severity of constraints by focus group members using the following formula

Mean Severity Score = (Sum of severity scores of all FGD groups for each constraint)/(Number of FGD groups)

To facilitate interpretation, the computed severity score values (ranging from 1 to 5) were categorized into five descriptive levels based on the mean scores, as 1.00 – 1.79 as Very Low; 1.80 – 2.59 as Low, 2.60 – 3.39 as Moderate, 3.40 – 4.19 as High and 4.20 – 5.00 as Very High. These categories helped to identify which constraints were most severe and required priority attention. The final data was presented as a ranked list for easy understanding.

HIGHLIGHTS

- Awareness was the binding constraint. Only 22% of 900 surveyed farmers were aware of LRI; 78% never engaged with the programme at all.
- Training, not card delivery, drove adoption. Trained farmers utilised LRI information at 57.3% — nearly double the rate of card recipients overall (32.4%).
- Overall utilisation was critically low. Despite farm-level site-specific recommendations, only 6.6% of farmers actually used LRI information to make a cropping or nutrient decision.
- Recommendations conflicted with farmer realities. Promoting crop suitability change was the most severe implementation constraint (MSS 4.86), reflecting a fundamental mismatch between technically derived prescriptions and local farming priorities.

3 | RESULTS AND DISCUSSIONS

The Land Resource Inventory (LRI) developed for each micro-watershed and individual land parcel represents a substantive scientific investment — a farm-level planning tool intended to provide site-specific soil physical and chemical data, crop suitability classifications, and nutrient management guidance directly to farmers and Project Implementing Agencies (PIAs). Its potential to support evidence-based land use decisions, mitigate climate change impacts, and optimise resource use is widely suggested in the literature (Hegde *et al*., 2018; Ravi *et al*., 2022b; Singh *et al.,* 2022). However, this potential can only be realised through effective dissemination, adequate capacity building, and actual farmer-level adoption. The results presented below systematically examine where, and by how much, the Sujala-III LRI programme fell short of this objective.

3.1 | LRI Information Dissemination and Awareness

Data gathered from household surveys across all 20 micro-watersheds (n = 900) reveal critically low levels of LRI awareness among watershed beneficiaries.

Only 198 farmers (22.0%) reported are aware of LRI or its recommendations. The remaining 78% had no knowledge of either the LRI or its operations. Qualitative interactions during the survey further indicated that the majority of unaware respondents believed the watershed project to be primarily a government programme for physical infrastructure like building farm ponds and bunding. However, no knowledge of any site-specific farm-level LRI information. This finding is consistent with the earlier monitoring and terminal evaluation of 12 Sujala-III micro-watersheds in four districts of Karnataka (Ravi *et al*., 2022 b), confirming that poor LRI dissemination is not an isolated or localised phenomenon but a systemic limitation of the programme's implementation. Of the 900 households surveyed, 182 (20.2%) had received LRI cards generated for their individual land parcels — a marginal shortfall even relative to the already-low awareness figure, suggesting that a small number of farmers possessed cards without having been meaningfully informed about their purpose or content. Only 103 farmers (11.4%) reported receiving LRI training, reflecting limited contact with LRI extension managers and insufficient capacity-building outreach across the watersheds. The high farmer-to-extension-manager ratio within the programme appears to have structurally constrained the frequency and quality of interaction between project staff and beneficiaries.

TABLE 1 Basic details of micro-watersheds selected for Impact assessment

District	Selected MWS	Average Annual Rainfall	Sample Size	
			MWS	SWS
Bidar	Babulgaon-2 (UR)	900	45	
	Kharanji Khurd (MR)	900	45	135
	Raipalli-2 (LR)	900	45	
Vijayapura	Mulwad-1 (UR)	625	45	
	Mulwad-3 (MR)	625	45	135
	Mulwad Tanda-2 (LR)	625	45	
Koppal	Chikkamyageri-3 (UR)	581	45	
	Ryavanaki-1 (MR)	581	45	135
	Bedwatti-6 (LR)	581	45	
Ballari	Vaddarahalli (UR)	722	45	
(erstwhile Davanagere)	Hallikeri-2 (MR)	608	45	135
	Honnenahalli (LR)	580	45	
Tumkur	Lingapura (UR)	990	45	
	Kalyanpura (MR)	990	45	135
	Huliyapura-1 (LR)	990	45	
Chikkamagaluru	Dasarahalli-1 (UR)	939	45	
	Dasarahalli 2 (MR & LR)	939	45	90
Chamarajanagara	Harve -2 (UR)	751	45	
	Sagade (MR)	751	45	
	Kumachahalli-1 (LR)	751	45	135

Note: UR – Upper Reach; MR – Middle Reach; LR – Lower Reach; MWS – Micro-watershed; SWS – Sub-watershed.

TABLE 2 LRI information dissemination, capacity building, and awareness status among watershed farmers (n = 900)

Particulars	Frequency	Percentage (%)
Awareness of Land Resource Inventory	198	22.00
Farmers who received an LRI card	182	20.22
Farmers who received LRI training	103	11.44
Farmers who utilised LRI information for crop selection or nutrient decisions	59	6.56
Farmers who read their LRI card more than once	26	2.89
Farmers who could recall site-specific LRI details of their own land parcel (at time of survey, 2024)	53	5.89
Farmers with LRI card present at time of survey	140	15.56

3.2 | The Dissemination-to-Adoption Chain: A Funnel Analysis

To understand the cumulative attrition from programme investment to actual farmer-level use, the dissemination data are best examined as a sequential chain rather than as isolated statistics. Table 3 presents the LRI adoption funnel, tracing the movement of farmers from initial survey population through awareness, card receipt, training, and active utilisation.

First, the overwhelming majority of programme loss occurs at the very first stage. Of the 900 farmers surveyed, 702 (78.0%) never became aware of LRI at all. Every failure downstream of this point is secondary to this foundational dissemination deficit. No amount of improvement in card quality, training content, or extension messaging can benefit farmers who have never heard of the site-specific land resource information.

Second, the drop between card receipt and training (43.4% of card recipients did not receive training) represents the critical conversion bottleneck in the chain. At this stage, the project had already invested in physical card delivery yet nearly half of card recipients received no follow-up capacity building. This gap between physical delivery and meaningful engagement is a key leverage point for intervention.

Third, and most analytically significant, training was the most decisive factor in driving utilisation. Among all farmers who received LRI cards, only 32.4% (59 of 182) went on to use the information. Among farmers who received training specifically, 57.3% (59 of 103) utilised the information — a utilisation rate nearly double that of the overall card-recipient group. This finding, strongly suggests that training, not card distribution, was the programme's primary adoption mechanism. It implies that expanding card distribution without a commensurate investment in training would yield diminishing returns.

Fourth, sustained engagement was low even among successful first adopters. Of the 59 farmers who used LRI information at least once, only 26 (44.1%) read their card more than once. This pattern suggests that even successful initial adoption did not lead to habitual reference behaviour, indicating a need for periodic follow-up contact rather than single-instance training events.

The LRI adoption efficiency ratios calculated for different indicators were presented in (Table 4) shows overall utilisation rate of 6.6% appears modest, the training conversion rate of 57.3% indicates that the intervention itself, when delivered, was reasonably effective. The problem is not that LRI recommendations are inherently difficult to adopt; it is that the conditions enabling adoption (awareness, card delivery, and particularly training) reached only a small fraction of the intended beneficiaries.

TABLE 3 Dissemination-to-adoption funnel and stage-wise attrition in LRI uptake

Stage	Number	% of Total (n=900)	Loss from Prior Stage	Loss (% of Prior Stage)
Total surveyed	900	100.0	-	-
Aware of LRI	198	22.0	702	78.0%
Received LRI card	182	20.2	16	8.1%
Received LRI training	103	11.4	79	43.4%
Utilised LRI information at least once	59	6.6	44	42.7%
Read LRI card more than once	26	2.9	33	55.9%

TABLE 4 LRI adoption efficiency indicators

Indicator	Numerator (observed outcome)	Denominator (Intervention exposure)	Value
Card utilisation rate (among card recipients)	59 used information	182 received cards	32.4%
Training conversion rate (among trained farmers)	59 used information	103 received training	57.3%
Training coverage rate (among card recipients)	103 trained	182 received cards	56.6%
Sustained engagement rate (among first adopters)	26 read card > 1 time	59 utilised at least once	44.1%
Overall programme utilisation rate	59 utilised	900 surveyed	6.6%

3.3 | LRI Card Availability and Utility at the Time of Survey

Physical availability of LRI cards at the time of the 2024 survey presented in (Table 2) provides a further indication of programme engagement. Of the 182 households that received LRI cards during implementation (2014–2019), 140 (15.6% of total respondents; 76.9% of card recipients) still had their card present at the time of the survey. Approximately 5% of respondents reported receiving a card but were unable to produce it, suggesting cards had been misplaced or discarded shows these results are consistent with low utility and engagement. Survey interactions indicated that in the majority of cases where cards were retained, they were stored at home and had not been actively utilized. Only 5.89% of all surveyed farmers could spontaneously recall site-specific LRI details of their own land parcel, confirming that card retention did not translate into card use. These findings corroborate (Ravi *et al*., 2022b), who noted that LRI cards were treated by many farmers as administrative documents rather than functional planning tools. The absence of repeated extension contact after initial distribution appears to have been a primary reason for this outcome.

3.4 | Farmer-Level Constraints in the Adoption of LRI Interventions

Data on adoption constraints were collected through open-ended questioning of all 900 household respondents, allowing farmers to identify constraints in their own terms rather than selecting from a pre-defined list. Since no prior literature had documented LRI-specific adoption constraints, this approach was necessary to capture the full range of perceived constraints. Responses were grouped into three thematic categories: knowledge and awareness constraints; constraints in adopting horticulture and agroforestry interventions; and constraints in adopting site-specific soil and water conservation (SWC) measures. Multiple constraints per respondent were counted. Findings are presented in Table 5 and discussed below.

TABLE 5 Farmer-level constraints in the adoption of LRI interventions (n = 900, multiple responses counted)

Constraint	Frequency	Percentage (%)	Rank
Knowledge and awareness constraints			
Lack of awareness of site-specific LRI information	630	70.00	I
Not interested in adopting new practices (conservatism/ traditional mindset)	36	4.00	VII
Lack of training on utilisation and adoption of LRI card	28	3.11	IX
Lack of education / illiteracy in understanding LRI	22	2.44	XI
Horticulture and agroforestry adoption constraints			
Water scarcity limiting survival of horticulture and agroforestry plantings	315	35.00	II
Lack of follow-up care by farmers after planting	96	10.67	III
Poor seedling quality leading to low survivability	86	9.56	IV
Unseasonal distribution of horticulture and forestry saplings	52	5.78	VI
Soil and water conservation adoption constraints			
Lack of farmer priority or need alignment in intervention selection	68	7.56	V
Land shortage or small holdings limiting adoption of SWC measures	32	3.56	VIII
Poor construction quality of SWC structures	27	3.00	X
Difficulty in movement between fields due to bunds	12	1.33	XII

3.4.1 | Knowledge and Awareness Constraints

Most respondents (70%) reported lack of awareness of site-specific LRI information as the main constraint, reflecting dissemination issues discussed in Section 3.1. This shows awareness, is the key constraint. Many farmers weren't resisting adoption but simply uninformed of available farm-level information. Among those with LRI cards, 3.11% lacked training on interpretation, indicating delivery without instruction led to uninformed possession. This aligns with Ravi and Patil (2022a), who found skills gaps among extension workers hinder effective dissemination. Without confidence among frontline workers, farmers struggle to understand LRI data. Illiteracy was a barrier for 2.44%, given the technical content requiring numeracy and literacy. An additional 4.0% cited conservatism or traditional mindsets as barriers, though real livelihood risk often underpins risk aversion among smallholders, which LRI doesn't address.

3.4.2 | Constraints in Adopting Horticulture and Agroforestry Interventions

Water scarcity was the most significant sector-specific constraint, reported by 315 respondents (35.0%). Most study watersheds are in low-to-medium rainfall zones (580–939 mm annual average), and many experienced chronic water stress before project start. Under these conditions, the survival of newly planted horticulture and agroforestry saplings, which need reliable moisture during establishment, was seriously affected. This matches Ramesha *et al.,* (2024), who found below-average survival rates for planted saplings in LRI watersheds and partly blamed this on shorter implementation periods that led to rushed activity without enough survival-support measures. Lack of follow-up care by farmers after PIA-led planting was reported by 10.67% of respondents, and poor seedling quality by 9.56%. Both issues point to the same core problem. The shift from project-managed planting to farmer-managed maintenance lacked proper support, either in motivation or input quality. The unseasonal distribution of planting material, cited by 5.78%, further shortened survival windows by causing mismatches between planting timing and ideal conditions for establishment.

3.4.3 | Constraints in Adopting site-specific SWC Measures

A misalignment between recommended SWC interventions and farmer priorities or needs was reported by 7.56% of respondents — the fifth-ranked constraint overall. This figure, though smaller in absolute terms, carries significant qualitative weight. It indicates that some project interventions were implemented in ways that did not reflect farmers' expressed needs, reducing acceptance and long-term commitment to maintenance. Specifically, trench-cum-bunding (TCB) activities repeatedly caused conflicts; 3.56% of farmers said their small landholdings made large-scale TCB recommendations impractical, as they viewed them as reducing their productive land. An additional 3.0% reported poor construction quality of SWC structures, which weakened both functionality and farmer confidence in the technical recommendations supporting them.

3.5 | Project Implementation Constraints: Evidence from Focus Group Discussions

Seven Focus Group Discussions (FGDs) were conducted with PIAs across all seven study districts, each involving 6–12 project staff members, including Assistant Agriculture Officers and Watershed Assistants. Participants jointly assessed five key implementation constraints using a five-point Likert scale (1 = Very Low to 5 = Very High), and a mean severity score was computed across FGDs for each constraint. Results are presented in (Table 6).

The biggest challenge, rated Very High by PIAs, was convincing farmers to adopt crop suitability based on LRI recommendations. Unlike awareness issues, farmers actively resisted altering established cropping patterns, especially in annual crops, where multi-year commitments make farmers cautious. However, PIAs strongly agree that farmers can be easily persuaded to adopt recommended horticultural crops. Poor acceptance of site-specific advice was rated High, highlighting a gap between scientific recommendations and farmers' experience and risk management. This gap stems from lack of farmer input during planning, leading to recommendations that often didn't fit local needs or priorities. Constraints also included deviations from site-specific advice and farmers' perception of land loss from conservation, both rated High. Field staff sometimes adapted recommendations to gain farmer approval, but this reduced implementation fidelity and scientific consistency. Delays in receiving LRI cards from partners, rated Moderate, caused delays in training and capacity-building, negatively impacting adoption.

TABLE 6 Implementation constraints identified by Project Implementing Agencies

Constraint	Severity Level	Mean Severity Score (MSS)	Rank
Difficulty in promoting crop suitability adoption among farmers	Very High	4.86	I
Poor acceptance of site-specific recommendations by farmers	High	4.14	II
Deviation of site-specific interventions as per farmer preference	High	3.71	III
Smallholders' perceived loss of productive land from adopting conservation measures	High	3.86	IV
Untimely receipt of LRI details (LRI cards) from LRI partner agencies	Medium	3.28	V

Note: Severity categories: 1.00–1.79 = Very Low; 1.80–2.59 = Low; 2.60–3.39 = Moderate; 3.40–4.19 = High; 4.20–5.00 = Very High. MSS = Mean Severity Score computed across seven FGDs.

3.5.1 | Supply-side Versus demand-side Constraint Classification

Constraints in Sections 3.4 and 3.5 fall into two categories with different policy implications. Supply-side constraints stem from institutional failures, such as delayed LRI card delivery, limited training, poor seedling quality, seasonal distribution issues, and subpar construction of SWC structures. These can be addressed through administrative improvements within the current framework. Demand-side constraints relate to farmer behaviour, attitudes, and conditions *viz*. lack of awareness, conservatism, illiteracy, water scarcity, small land sizes, and misalignment with farmer priorities. These requires participatory, farmer-

centric approaches, like identifying appropriate behavior change communication methods for LRI dissemination and peer learning, rather than administrative fixes. Findings suggest supply-side issues, especially in dissemination and training, are major—causing 78% of awareness deficits. However, demand-side barriers become more influential as farmers progress, especially in crop adaptation and sustained engagement. Effective strategies should address both, starting with supply-side improvements, followed by demand-side engagement for lasting adoption.

3.6 | Where the LRI Programme Lost Its Farmers

Overall, the findings from Sections 3.1 to 3.5 depict a program with a solid scientific design that ultimately failed during various stages of implementation. Figure 1 and Table 3 explicitly illustrate this: out of every 100 farmers enrolled in the watershed program, about 22 became aware of LRI, 20 received a card, 11 attended training, and only 7 then used that information for farming decisions. The remaining 93 did not engage meaningfully with the LRI component. This isn't mainly due to farmer resistance. Data show that more than half of trained farmers used the information provided. The main issues were institutional—poor dissemination, limited training coverage, delayed card delivery, and a planning process that didn't sufficiently involve farmers in shaping recommendations. Improving program impact in future versions requires stronger extension links, earlier and ongoing farmer engagement, and integrating LRI data into existing agricultural services.

4 | CONCLUSIONS

This study is the first systematic effort to document LRI-related adoption hurdles in these watersheds, and its results are clear: despite the scientific rigor and genuine potential of the LRI approach, translating it into farmer practice has been seriously limited. The adoption funnel analysis, based on household survey data from 900 farmers across 20 micro-watersheds, shows a pattern of increasing attrition at each stage of the dissemination- to- adoption process. The overall usage rate of 6.6% despite investments in soil surveys, digital databases, and land resource cards highlights a significant gap between scientific design and actual field impact. This failure is not only due to farmer resistance or structural barriers. The cross- stage ratios indicate that training was the most critical factor for utilization: among trained farmers, 57.3% used LRI information, 32.4% among all card recipients. This shifts the focus of the adoption challenge *viz*. understating and awareness, card distribution, and especially training reached only a small portion of intended farmers. The constraints analysis supports this interpretation. From farmers' perspective, lack of awareness was the main barrier, reported by 70%, far exceeding all other constraints combined. From the PIA viewpoint, the biggest challenge was the difficulty in promoting crop suitability changes, rated Very High severity (mean score 4.86), indicating a deeper structural issue: LRI recommendations were created without enough participatory input from farmers, leading to a mismatch between scientific prescriptions and local farmer needs. Delays in delivering LRI cards from partner agencies (Moderate severity, MSS 3.28), though ranked lower among implementation constraints, directly impacted training opportunities by reducing the time available for capacity building. Overall, these findings suggest that the Sujala- III LRI programme faced shortfall on two levels. Supply- side issues such as dissemination, training coverage, timing of card delivery, and input quality which prevented most farmers from accessing the programme' s information. Demand- side barriers like conservatism, illiteracy, water scarcity, small landholdings, and misalignment with farmer priorities which restricted adoption among those who did receive information. Addressing both types of barriers is essential for future LRI programmes to reach their full utilization potential and justify the scientific investments made.

Based on the findings of this study, the following recommendations are ordered by intervention priority, based on severity from FGD data and the funnel analysis's attrition structure. They target three levels: programme design, institutional integration, and field implementation.

4.1 | Prioritize training over card distribution as the main adoption method

The study finds that training, not card delivery, drives LRI use. Future programs should focus on training as the main investment, with card distribution supporting rather than leading. Coverage must increase from 11.4% to at least 60–70%, monitored based on outcomes, not just card counts. Training should involve multiple, repeated contacts, not single sessions are essential to turn initial use into sustained practice.

4.2 | Deploy progressive farmers as para-extension workers for LRI dissemination

The high farmer-to-LRI extension manager ratio limits individual contact, which cannot be fixed by just adding more professional staff. Instead, identify and train successful farmers as community-level para-extension workers, a model used in Indian agriculture under ATMA. They can provide peer demonstrations and support cheaper than formal extension and are more credible among neighbours due to shared experience. Further training should start early in the programme, not after it ends.

4.3 | Integrate LRI data into existing agricultural systems

Currently, the LRI database is a standalone resource used only within the Sujala-III programme. Its effectiveness would increase if integrated into routine service delivery of state agricultural institutions. LRI data should connect to subsidy and input processes at Raitha Samparka Kendras (RSKs) and State Agriculture Department points, so farmer-specific LRI recommendations are accessible when registering for seeds, fertilisers, or crop insurance. This model, similar to Aadhaar-enabled targeting, would institutionalize LRI access and enhance transparency by offering site-specific recommendations instead of generic

advisories.

4.4 | Reform planning to include participatory farmer input during LRI design

The main implementation challenge identified by PIAs are difficulty in promoting crop suitability change is a planning issue, not communication. LRI recommendations conflicting with cropping patterns, landholding, and water conditions won't be adopted unless farmers are involved early in shaping these plans. Future planning should involve structured consultations with farmer groups before finalising site-specific recommendations, ensuring crop suitability and SWC prescriptions are co-developed with communities.

4.5 | Address logistical issues in card delivery and planting material distribution

The delayed receipt of LRI cards from partners, rated Moderate, hampers training and capacity building timelines. Programme agreements should include binding delivery deadlines, with cards available to PIAs before the first implementation season. Unseasonal distribution of horticulture and agroforestry planting material, which hurt sapling survival, should be managed through procurement calendars aligned with optimal planting windows and quality nursery materials.

4.6 | Develop accessible, multi-format LRI communication materials

Since 2.44% of farmers reported illiteracy and many lacked the vocabulary to interpret LRI outputs, a suitable extension communication methods to be evolved to make farmers to understand LRI science in local language. Digital delivery through farmer mobile apps, linked to geo-referenced land data, would improve accessibility for smartphone users while reducing the risk of card loss.

4.7 | Establish LRI as a continuous resource instead of a project-based one

Currently, LRI is a project deliverable produced during implementation and distributed at the end of funding. This model hinders sustained use, as it lacks mechanisms for updating recommendations, addressing farmer queries after project closure, or integrating outputs into ongoing planning. Hence government should develop a framework for ongoing maintenance and public access, with periodic updates and integration into the National Soil Health Card scheme to utilize existing infrastructure and farmer familiarity.

4.8 | Future research should address several gaps

Comparing adoption rates and outcomes in LRI versus non-LRI watersheds can clarify LRI's specific impact. Documenting the gap between LRI crop recommendations and farmer decisions at the field level can reveal whether inadequate advice, poor communication, or farmer adaptation is to blame. Finally, evaluating extension functionaries' skills in LRI interpretation and communication can identify capacity gaps and guide targeted training.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this work.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the first author and corresponding author upon reasonable request.

AUTHOR'S CONTRIBUTION

All authors contributed to the conception and design of the study. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was written by the first author and the corresponding author, who contributed equally to this work. All authors provided substantial inputs, reviewed and revised previous versions of the manuscript. All authors read and approved the final manuscript.

REFERENCES

Bandyopadhyay, S., Ghosh, B. N., Ray, P., Ramachandran, S., Jena, R. K., Roy, P. D., Singh, S. K., Mukhopadhyay, S., Nayak, D. C., & Ray, S. K. (2018). Impact assessment of land resource inventory towards optimizing land use plan in Brahmaputra valley ecosystem, Assam, India, *Indian J. Soil Conservation*, 46(1), 11-24.

Bandyopadhyay, S., Jaiswal, R. K., Hegde, V. S., & Jayaraman, V. (2009). Assessment of land suitability potentials for agriculture using a remote sensing and GIS based approach, *International Journal of Remote Sensing*, 30(4), 879-895.

Hegde, R., Niranjana, K. V., Srinivas, S., Danorkar, B. A., & Singh, S. K. (2018). Site-specific land resource inventory for scientific planning of Sujala watersheds in Karnataka. *Current Science*, 115(4), 610–613.

Jat, R. A., Jinger, D., Kumawat, A., Kar, S. K., Rawat, I., Kumar, S., Paramesh, V., Meena, V. S., Kaushal, R., Kumar, K., Meena, H. S., Wani, S. P., Singh, R., & Madhu, M. (2025). Integrated watershed management for transforming dryland livelihoods: A climate-smart strategy for sustainable dryland agriculture in India. Watershed Ecology and the Environment, 7, 159–177. ISSN 2589-4714.

Jayaraman, S., Naorem, A., Sinha, N.K.,Madhu, M. and Dalal, R.C. 2024. Combating land degradation:Global challenge, local solutions. *Indian J. Soil Cons.*, 52(Global Soils Conference - 2024 Special Issue): S74-S84.DOI: 10.59797/ijsc.v52.i2.161

Kumar, A., Choudhary, A. K., Suri, V. K., Bana, R. S., Pooniya, V., & Singh, U. (2014). Site specific water management for sustainable agriculture. In: Meena, M. S., Singh, K. M., & Bhatt, B. P. (Eds.), Water Management in Agriculture (pp. 327-336). Jaya Publishing House, New Delhi.

Lalitha, M., Dharumarajan, S., Natarajan, A., Niranjana, K. V., Srinivas, S., Naidu, L. G. K., & Sarkar, D. (2016). Need for site specific land resource database for integrated watershed management, *Indian J. Soil Conservation,* 44(2), 168 -176.

Mishra, P.K., Sena, D.R., Pande, V.C.and Singh, R.K. 2024. Framing land degradation and restoration policy in India following the IPBES pathway Indian J. Soil Cons., 52 (Global Soils Conference - 2024 Special Issue): S14-S25.DOI: 10.59797/ijsc.v52.i2.154

National Bank for Agriculture and Rural Development (NABARD). (2023). Watershed Management. Annual Report 2023–24. NABARD

Ramamurthy, V., Singh, S. K., Chattaraj, S., Reddy, G. O., & Kumar, S. R. (2016). Land resource inventory towards village level agricultural land use planning. In: Obi Reddy, G. P., Patil, N. G., & Chaturvedi, A. (eds.), Sustainable Management of Land Resources (pp. 643-668). Apple Academy Press.

Ramesha, M. N., Patil, S. L., Ravi, K. N., Naik, B. S., Dupdal, R., & Morade, A. S. (2024). Climate, skill proficiency and farmers motivation have an interplay in success of horticulture and agroforestry interventions in the watershed: A case study. *Ecology, Environment and Conservation* 30 (3): 1348-1352.

Ravi, K. N., & Patil, S. L. (2022a). A scale to measure core competency of extension field functionaries in land resource inventory-based watersheds. *Gujatat Journal of Extension Education*. 33(1), 1-7.

Ravi, K. N., S. L. Patil, Hrittick Biswas, M. N. Ramesha, B. S. Naik, P. R. Ojasvi, Ravi Duppal, M. Prabhavathi, Suresh Kumar, and A. S. Morade. (2022b). Land resource cards: An innovative approach to empower farmers for site-specific farm resource management. *Indian Journal of Extension Education* 58 (1): 106-110.

Singh S.K., Mohekar D.S.R., Arunachalam V., Kumar N. Chattaraj S., Jenna R.K. Das B. & Kumar P. (2022). Land resource inventorying (LRI) on 1:10K – National soil priority of India. *Geoderma Regional*, 29, e00524. https://doi.org/ 10.1016/j.geodrs.2022.e00524

Zerga, B. (2025). Integrated watershed management: a review. *Discover Sustainability* 6, 657. https://doi.org/10.1007/s43621-025-01352-0.

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