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EDITORIAL

Indian Council of Agricultural Research has developed India's first genome-edited rice varieties– DRR Rice 100 (Kamla) and Pusa DST Rice 1, with the potential for revolutionary changes in higher production, climate adaptability, and water conservation. About 56% of respondents globally supported the use of such breeding techniques, which can change the genetic makeup of organisms, if that meant crops could be more resistant to climate change. Viksit Krishi Sankalp Abhiyan (VKSA), a 15-day nationwide agricultural outreach campaign by the Union Ministry of Agriculture and Farmers' Welfare, India aimed to bridge the gap between scientific research and grassroots farming and could reach 1.36 crore farmers in a fortnight, in 700+ Indian districts. It embodied the vision of "Lab to Land", empowering farmers with knowledge to improve productivity and income. VKSA promoted modern farming techniques, soil health awareness, natural farming, and crop diversification. The programme focused on drawing the agenda for agricultural policies in open fields, in direct consultation with farmers. It will pave the way for restructuring the extension system with clearly defined, non-overlapping roles and robust, structured learning programmes for the stakeholders.

The current issue (July-September, 2025) contains four research tools, seven research notes, and sixteen full-length research papers. The diversity of full length papers focused on; An ANN Model Integration on Perception of Paddy Farmers on Climate Change, Aquaculture Practices and Knowledge Level of Fish Farmers, Predictive Role of Cyberbullying and Victimization on General Psychological Distress among PhD Students, Evaluating MGNREGA's Role in Boosting Agricultural Performance, Effect of Joint Liability Groups on the Improvement of Paddy Farming, Transformation of Intergenerational Farming Knowledge in Toto Tribal Communities, Farm Mechanization and Farmers' Preferences, Institutional Engagement and Its Role in Livelihood Transformation of Tribal Coffee Farmers, Rural Teachers' Quality of Life Through Physical, Psychological, Social, and Environmental Lenses, Effectiveness of Climate Resilient Interventions on Performance of Dairy Animals, Evaluating the Effect of Extension Advisory Services using Economic Index Score, Adoption of Climate-Smart Agriculture in Flood-Affected Regions, Role of Cognitive Style in Academic Achievements and Creative Thinking among Students, Digital Shift Reshaping Adolescents Lifestyle, Mapping Socio-Economic and Entrepreneurial Diversity among Makhana Farmers through Cluster Analysis, and Factors Influencing Farming Practices towards Nutrition Sensitive Agriculture. Four research tool covered: Farmers' Attitude towards Indigenous Cattle Conservation, Farmers' Attitudes towards Scientific Backyard Poultry Farming, Knowledge Tool for Semi-Intensive Pig Production, and Attitude of Farmers towards the Maize and Wheat Crops. The research notes majorly focused on; Interpersonal Communication Skills in Shaping Academic Performance, Barriers Hindering Tribal Farm Women's Access to Agri-Allied Information farmer perceptions of trees on farms, Constraints and Satisfaction of Makhana Growers, Constraints and Strategic Suggestions for Enhancing Integrated Farming Systems, Millet Adoption in Bundelkhand and Resource Use Efficiency and Marginal Productivity of Potato Cultivation.

The Scopus cite score for 2024 was released on June 06, 2025, and the journal received 1.2 with SJR of 0.234, an SNIP of 0.305, and Resurchify Impact Score of 1.1. (https://www.scopus.com/sourceid/21100846015), speaking about the increasing international impact.

I, on behalf of the editorial board, extend my sincere thanks to all those who directly or indirectly assisted the editorial board. We acknowledge the contribution made by the reviewers by including their names. We acknowledge Ms. ACS publisher, for maintaining the timeline. All the expert members of the editorial board and willing contributors are sincerely acknowledged. The support extended by the Executive Council is duly acknowledged. Special thanks are extended to Dr. U.S. Gautam, Dr. Satyapriya, Dr. Keshava, Dr. Basvaprabhu Jirli, and Dr. Bhanu P. Mishra for their insightful thoughts and guidance.

(Manjeet Singh Nain)
Chief Editor

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Perception of Paddy Farmers on Climate Change in Western Odisha: An ANN Model Integration

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HIGHLIGHTS

- The study focuses on the Paddy farmers' perception of climate change and its cause.
- The study supports that perception by itself does not guarantee adaptation, highlighting the need for focused capacity-building initiatives.
- Neural network architecture developed by identifying ideal hidden nodes per component, minimizing Mean Square Error (MSE), and enhancing model accuracy.

ARTICLE INFO

Keywords: Artificial neural network, Climate change, Farmers perception, Socio-economic factors, Western Odisha.

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Informed consent of the participants

ABSTRACT

The study, conducted during 2024-25, to examine Paddy farmers' perception of climate change in Balangir and Kalahandi districts of Western Odisha, an Artificial Neural Network (ANN) model was integrated to analyse the relationship between socio-economic factors of Paddy farmers and their perception of climate change. A total of 180 farmers were interviewed with a structured interview schedule to evaluate their perceptions of three main components, *viz.,* exposure, sensitivity, and adaptive competence. The majority of farmers strongly agreed that climate variability, including erratic rainfall, rising temperatures, and extreme weather, adversely impacts agricultural production and causes a serious threat to food security, and changes in climatic conditions lead to shifts in cropping patterns. An ANN model identified the best hidden nodes, i.e., (3,3) for both the exposure and sensitivity, and (5,3) for the adaptive competence component, achieving a minimum Mean Square Error of 7.726 for the best neural network architecture.

INTRODUCTION

Climate change encompasses long-term shifts in Earth's climate. According to World Meteorological Organisation (2024), nearly 50% possibility that average global temperature over next five years rise by more than +1.5°C between 2024-2028. Intergovernmental Panel on Climate Change (IPCC) in 2030 predicts that the 20-year average temperature rise more than 1.5°C (IPCC, 2021). Vigorous climate change has been observed throughout the first few decades of 21st century; since systematic monitoring began in 1850, 2024 has been the warmest year on record, with temperature rise of 1.60 °C (Global Climate Highlights, 2024).

The threat that climate change poses to agriculture in general and food security in particular has given the country's already pressing issues a new dimension (Ghanghas et al., 2015; Rao et al., 2016; Pathak et al., 2024; Mishra et al., 2024). India has also been recognised as one of the most vulnerable nations to climate change. (Indian Network on Climate Change Assessment, 2010). Recent research revealed that there are incidents of severe cyclonic activity, catastrophic precipitation events, droughts, heat waves, and

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temperature rise in India (Rohini et al., 2016; Sharma & Majumder, 2017; Ray et al., 2019; Pavan Kumar et al., 2023). Based on the farmers' voice study in 2024, over 75% of farmers are already affected by climate change and concerned about its effects, and 71% of them say that lower yields are a key concern (Vu et al., 2025; Sahoo et al., 2025).

Odisha is a hotspot for climatic phenomena and boasts 480 kilometres (km) of coastline that stretches from West Bengal to Andhra Pradesh. Due to its location and geophysical circumstances, Odisha is particularly affected by climate change (Meher, 2024). Poverty and present growth methods could be disrupted by climate change. Events brought on by extreme climate change might directly result in loss of life, livelihood, property, and infrastructure (Hussain et al., 2024). Kalahandi and Balangir, these two districts of KBK (Kalahandi-Balangir-Koraput) region, these are the backward districts of Western Odisha, have grown susceptible to frequent droughts and famine-like conditions, which have caused the impoverished to migrate in despair during the non-agricultural season. Majority of people in Odisha's KBK districts live Below the Poverty Line (BPL), making them one of the state's poorest areas (Panda et al., 2019). Additionally, these districts have seen more migration, diseases, and famine due to recurrence of drought and floods. However, various factors, including erratic rainfall patterns, insufficient irrigation, and rise in frequency and severity of natural disasters, are causing agricultural productivity to become increasingly unstable (Kumar & Saxena, 2024). Agriculture is most susceptible to climate change, and Paddy is most water dependent, and about 60 per cent of its land dependent on monsoon (Rao et al., 2015; Panda & Parashari, 2025). The state's food grain production depends on climatic conditions, and frequent climate variability have long-term effects on the production pattern.

METHODOLOGY

The study was conducted in 2024 at Balangir and Kalahandi districts of Western Odisha. These two districts are part of the KBK region, are among the poorest in the state, and the majority of the population lives below the Poverty Line (BPL). By using a simple random sampling technique, 15 villages were chosen from each district. Six farmers were selected randomly from each 30 selected villages, and a total of 180 Paddy farmers were selected as sample respondents of the study. Data was collected using a pre-tested, structured interview schedule. A total of 32 statements on farmers' perception towards climate change, out of which 26 statements were positive and 6 statements were negative (Scale developed by Govindbhai, 2023). An attempt was made to establish the machine learning approaches, *i.e.* the Artificial Neural Network (ANN) model. A computational model that draws inspiration from the architecture and operations of biological neural networks is called an artificial neural network (ANN), ANN technique is used for building such a model (Gupta & Raza, 2019). The training set is used to develop the neural network, while the testing set is used to validate the model. The model's performance was evaluated using the Mean Square Error (MSE). An input layer, one or more hidden layers, and an output layer make up this structure. Interconnected neurons with corresponding weights and biases are used to model the functional relationship between input variables and output. In the ANN model, a neuron's output y can be shown as

$$y = \gamma\left(\sum_{i=1}^{n} w_i x_i + b\right)$$

Where, x_i = Input variables, w_i = Weights assigned to every input, b = Bias term, γ = Activation function, y = Output of the neuron

RESULTS

Table 1 presents the key findings on component-wise distribution of respondents based on their perceptions of climate change. Majority of Paddy farmers strongly agreed with the following climate change statements like 89.44 per cent were strongly agreed that extreme weather condition adversely affects agricultural production followed by 86.66 per cent on temperature increase or decrease every year is cause of climate change, 83.33 per cent on increasing rainfall fluctuations and 80.55 per cent on high-intensity rainfall due to increasing global temperature. 92.77 per cent strongly agreed that climate change created a significant threat to food security followed by erratic monsoon rainfall increases crop water demand (90.55%), 86.66 per cent were believed that agricultural biodiversity is threatened by decreased rainfall and rising temperatures and 83.33 per cent were strongly agreed that climate change has resulted in the extinction of flora and fauna. Majority were strongly agreed with the statement that cropping patterns are changing due to climatic conditions (94.44%) followed by believed that extreme weather events have caused changes in crop productivity (90.55%), irrigation methods have changed due to altered rainfall and high temperatures (87.77%) and 85.55 per cent were strongly agreed that cost of cultivation has increased due to higher pest and disease control expenses.

Artificial Neural Network (ANN) model

Before applying the neural network, the dependent and independent data series were separated into training and testing sets in 75 per cent and 25 per cent, respectively. There was no such esteem observation found in the data series. Hence, all 180 data points for all variables were considered for the research. Table 2 provides all the details of the architecture and hyperparameter information of the ANN. Thirteen input variables were utilised as covariates in the analysis, and the normalised with min - max scaler technique was used to adjust the covariates. To enhance network training, scale-dependent variables and covariates were default to rescaled. Even if a testing dataset was specified, all rescaling was done using the training data. Thirteen input nodes made up the network's input layer; the number of covariates in the input layer corresponded to the number of nodes. There were thirteen nodes in two hidden layers and one output layer with a single node. The hidden layers employed a hyperbolic tangent activation function (TANH), which converted real-valued arguments into a range between -1 to 1. Since the output layer was subjected to the identity activation function, the error was the mean square error. It accepted a vector of real-valued parameters and transformed it into a vector with components falling within the range (0 to 1) and a total sum of one.

Table 1. Perception of climate change

S.No.	Statements	SA	A	UD	D	SD
I.	Exposure					
1	Rainfall fluctuation is more common these days	83.33	16.66	0	0	0
2	The temperature increases or decreases every year is caused by climate change	86.66	13.33	0	0	0
3	Rainfall duration has changed as a result of more extreme weather	83.33	16.11	0.55	0	0
4	High intensity of rainfall due to the increasing global temperature	80.55	19.44	0	0	0
5	Temperature changes have little effect on agricultural production	0	0	0.55	6.66	92.77
6	Extreme weather conditions adversely affected agricultural production	89.44	10.55	0	0	0
7	Sunshine hours become hotter due to extreme heat events	75.55	24.44	0	0	0
8	More intense dry summer winds due to the very high temperature	65	35	0	0	0
9	Farming operations are impacted by the extremely cold temperatures, high winds, and dense fog	66.66	31.66	1.66	0	0
10	Heat stress is proving harmful for the crops as cause of the rise in temperature	76.66	22.22	1.11	0	0
II.	Sensitivity					
1	Climate change poses a significant threat to food security	92.77	6.11	1.11	0	0
2	Crop yield is decreased as a result of altered rainfall patterns during the monsoon season	0.55	0.55	0.55	37.22	61.11
3	There is an increase in crop water demand as a result of erratic rainfall during the monsoon season	90.55	7.22	2.22	0	0
4	Agricultural biodiversity is threatened by decreased rainfall and increased temperature	86.66	12.77	0.55	0	0
5	Extreme weather events are caused by a larger loss of soil nutrients into rivers	61.66	37.22	1.11	0	0
6	Livestock rearing has become more vulnerable due to climatic conditions like heat stress	69.44	29.44	1.11	0	0
7	Weed and insect pest incidence become more common due to changes in extreme weather	74.44	23.88	1.66	0	0
8	There is an increasing incidence of crop diseases nowadays compared to earlier times	81.66	17.22	0	1.11	0
9	The quality of crop yields has decreased as a result of variations in temperature and rainfall	0	0	1.66	29.44	68.88
10	Water shortage decreased because of variances in precipitation	1.11	0	1.11	34.44	63.33
11	Climate change has resulted in the extinction of flora and fauna	83.33	11.66	0	0	0
12	Climate change has made deforestation more severe	75.55	24.44	0	0	0
III.	Adaptive competence					
1	Changes in weather patterns make it more difficult to plant and harvest crops	0	0	0.55	18.88	80.55
2	Cropping patterns are changing because of a change in climatic conditions	94.44	4.44	0	1.11	0
3	Crop varieties are not adaptive to changing climatic conditions	0.55	0	0.55	42.77	56.11
4	The method of irrigation changed due to a change in rainfall patterns or high temperatures	87.77	11.66	0	0.55	0
5	The cost of cultivation increased due to more expenditure on the control of pests or diseases	85.55	13.88	0	0.55	0
6	Climate change has little effect on agricultural product transportation	0	0.55	0	26.66	72.22
7	Extreme weather events have caused changes in crop productivity	90.55	8.88	0	0.55	0
8	The declining groundwater table has made crop cultivation more challenging	77.77	22.22	0	0	0
9	Farmers' patterns of livelihood are shifting as a result of shifting weather patterns	70.55	29.44	0	0	0
10	Farmers' crop season and cropping techniques are changing as a result of climate change	76.66	22.77	0.55	0	0

SD-Strongly Agree, A-Agree, UD-Undecided, D-Disagree, SD-Strongly Disagree

Based on the architecture of ANN with the best hidden nodes of all components of the dependent series, the minimum Mean Square Error obtained from the testing set is represented in Table 3. The training set was used for developing a neural network, whereas the testing set was used to validate the model. The validation of the model is estimated by the Mean Square Error (MSE). It was found that the component from farmer perception on climate change, the Mean Square Error (MSE) was for exposure 2.501, for sensitivity 2.673 and adaptive competence 2,552, with a total of 7.726, provides enough evidence that the best neural architecture was developed (Figure 1).

DISCUSSION

The majority of the paddy farmers had experienced the effects of climate change, especially irregular rainfall and temperature fluctuations. However, few farmers remain unaware of adaptation measures due to limited access to information and a lack of communication with the extension agency, the findings were in line with Ansari et al., (2018) & Lahiri et al., (2024). In order to support farm-level decisions and minimize the loses in adverse climatic and weather conditions farmers' understanding about the interaction of climate and agro-ecosystem needs to be bridged through the inclusion of farmers' communication network (Ravikumar et al., 2015). Farmers recognise various climate threats; they frequently perceive their vulnerability but do not fully understand the severity of the long-term impacts of climate change, the findings derived supports from the results of Aidoo et al., (2021). Farmers were identified to have useful adaptation strategies like changes in crops, water use, and pest control, but their ability to adopt these strategies remains lower. This was due to limited availability of resources and lack of experience related to the climatic issue, the findings were partially in line up with Nduwayezu et al., (2023).

Table 2. Neural Network Information Summary

Layers	Covariates	1	Age
A. Input Layer		2	Gender
		3	Education
		4	Household Size
		5	Land Holding
		6	Framing Experience
		7	Credit access
		8	Framer Association Membership
		9	Extension agency contact
		10	Training Attended
		11	Mass Media Exposure
		12	Risk Experience
		13	Knowledge of Crop Insurance
	Number of Units	13	
	Rescaling Method for Covariates	Normalised (With min–max scaler)	
B. Hidden Layers	Number of Hidden Layers	2	
	Number of Units in Hidden Layers 1 and 2	3,3 Exposure 3,3 Sensitivity 5,3 Adaptive competence	
	Activation Function	Hyperbolic tangent	
C. Out Layers	Dependent Variables	1	Farmers' Perception on Climate Change (Exposure, Sensitivity, Adaptive Competence)
	Number of Units	1	
	Rescaling Method for Scale Dependents	Normalised (With min–max sealer)	
	Error Function	Mean Square Error (MSE)	

Table 3. Error Summary of Testing

Component	Mean Squares Error (MSE)
Exposure	2.501
Sensitivity	2.673
Adaptive competence	2.552
Total	7.726

Agencies and stakeholders assisting farmers in scaling up the adoption of climate smart agricultural practices, like precision conservation agriculture, should develop a shared understanding and strategy for promoting these cutting-edge technologies within farming communities (Shitu & Nain, 2024). By applying the best number of units in the hidden layer 1 and 2, *i.e.* (3,3) for both the exposure and sensitivity component and (5,3) for the adaptive competence component, to get the minimum Mean Square Error obtained from the testing data set and to validate the developed neural network architecture.

CONCLUSION

The study underlines that perception alone cannot drive adaptation; therefore, capacity-building initiatives are crucial to motivate farmers to solve their problems. Creating localized climate advisory services, promoting community-based extension services can be more resilient for sustainable farming community. Following improved agricultural methods, expanding credit access and knowledge on crop insurance, ensuring frequent extension services,

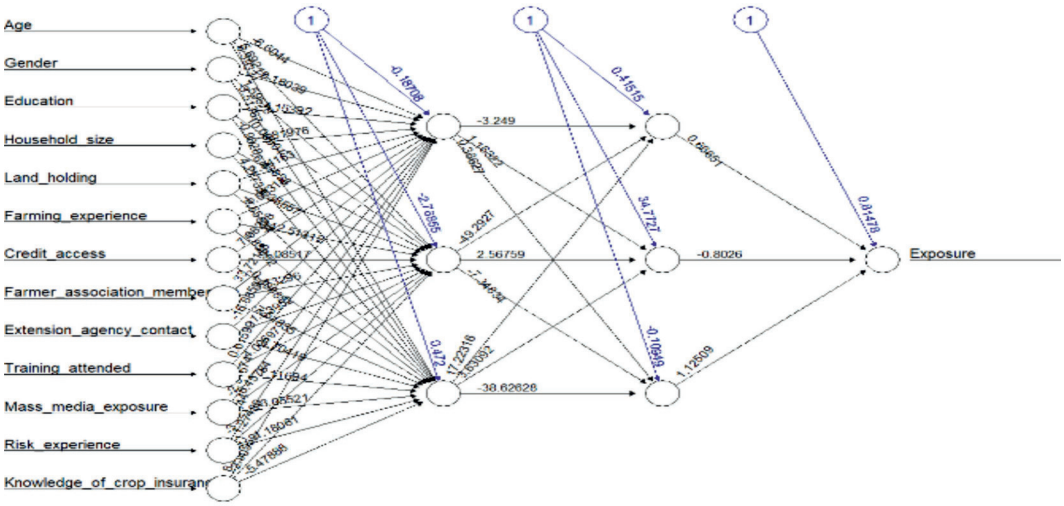

Figure 1a. Developed neural network architecture for farmers' perception of climate change based on the Exposure component

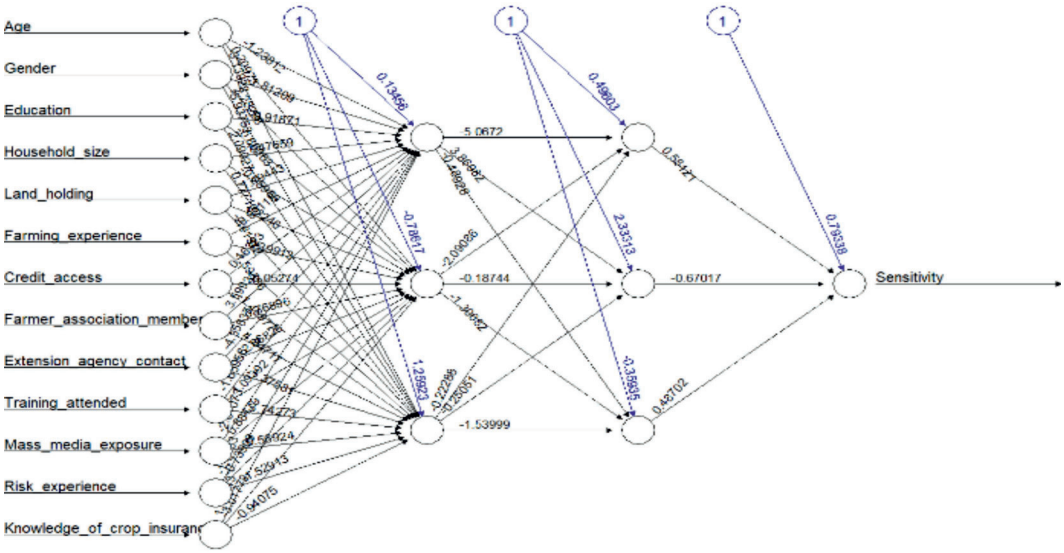

Figure 1b. Developed neural network architecture for farmers' perception on climate change based on the Sensitivity component

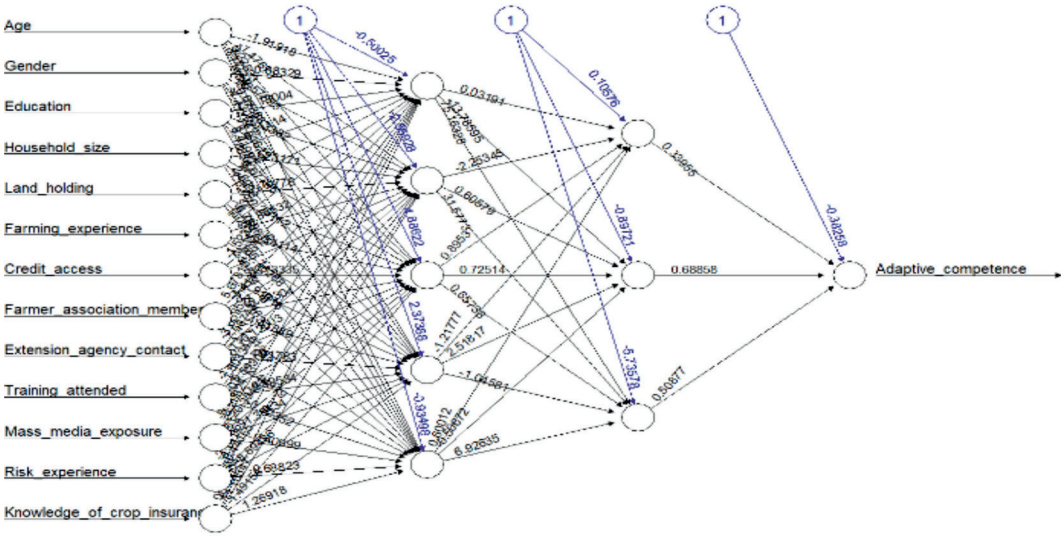

Figure 1c. Developed neural network architecture for farmers' perception on climate change based on the Adaptive competence component

and creating awareness on climate literacy among farmers are very essential approaches in the context of climate change. Predictive tools like Artificial Neural Networks (ANN) could effectively guide policymakers for sustainable agriculture. By addressing these key areas, policymakers can better assist vulnerable agricultural communities in Western Odisha in reducing climate risks and guaranteeing food security by tackling these issues.

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Aquaculture Practices and Knowledge Level of Fish Farmers in Purulia District of West Bengal

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HIGHLIGHTS

- The majority of fish farmers in the study area had low to medium level of knowledge about recommended aquaculture practices in the study area.
- Farmers faced critical challenges such as inadequate technical support and high input costs, limiting the effective adoption of improved fish farming methods.
- The study emphasizes the importance of technical guidance from experts, targeted need-based training and institutional backing to enhance scientific know-how regarding aquaculture.

ARTICLE INFO

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ABSTRACT

The study was conducted in the Purulia district of West Bengal during 2024–25, aimed to assess the state of aquaculture and the knowledge level of fish farmers. 120 fish farmers were individually interviewed to collect primary data. Most ponds were earthen (90.83%), rain-fed (68.33%), and seasonal (56.67%), with water retention for 6 to 9 months. Indian major carp were farmed by 86.67 per cent of the respondents through polyculture systems. Only 15 per cent used commercial feed, and 77.5 per cent monitored fish growth throughout the culture period. It was also revealed that 38.33 per cent had a medium level of knowledge, while 34.17 per cent had a low level of knowledge about recommended fish farming practices. It was further found that education, occupation, farming experience, mass media exposure, extension agency contacts, and economic motivation had strong relationships with the respondents' knowledge level ($p<0.01$). The majority of respondents faced constraints such as inadequate technical support for scientific fish farming (RBQ: 86.09) and high costs of input materials and skilled labour (RBQ: 85.4). A concerted educational effort with follow-up, stronger extension services, input subsidies, better water retention infrastructure, and mass media awareness is urgently needed in the area.

INTRODUCTION

Fishery and aquaculture significantly contribute to India's economy through income, nutrition, employment, and exports, evolving from traditional to commercial sectors with high potential (Mallick, 2017; India CSR, 2023; Mahanayak & Panigrahi, 2024), and act as a quick source of income for small-scale farmers, helping improve the socioeconomic conditions of rural areas (Singh et al., 2024 & Mondal et al., 2025). West Bengal is a leading fish-producing state in India, with fish production increasing significantly in recent years, with a total production of 20.45 lakh metric tons in 2022-23. If all water bodies are fully utilized, the total fish production in the state can reach approximately 33 lakh metric tons

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per year (Gazette, 2023). Purulia produces 48,928 metric tons of fish annually, contributing to the overall production in West Bengal (Purulia District Administration, 2025). Despite its contribution, Purulia ranks lower among West Bengal districts in terms of fish production because of limited water resources, and the estimated annual demand for fish is higher than its production, resulting in a deficit (Biswas et al., 2019). Purulia, a drought-prone district in West Bengal, is socioeconomically underdeveloped and largely inhabited by resource-poor communities, and poverty is prevalent in the region. (Mishra et al., 2022). The advancement of recommended aquaculture in Purulia, an economically underdeveloped district in India, faces multiple challenges related to socioeconomic conditions, terrain, and climate (Mishra et al., 2021). If the present water resources, such as ponds and tanks, are utilized properly for pisciculture, the production of fish will increase to a considerable extent, thereby increasing the scope of income and employment for rural people. Therefore, there is ample possibility of bringing more area under efficient pisciculture (Purulia District Administration, 2025).

There is significant potential to boost fish production, which relies on farmers adopting scientific practices, accessing formal financial support, receiving input from fishery departments, and improving their skills through targeted training programs (Ghosh et al., 2022; Mondal et al., 2025). Assessing fish farmers' knowledge is crucial for promoting a package of practices and effectively disseminating scientific fish culture techniques in rural conditions. This assessment serves as a foundation for designing future extension strategies (Rathore et al., 2016). Knowledge involves acquiring reliable facts and understanding how innovations work, and is an important factor in determining the success and sustainability of aquaculture practices (Kumar et al., 2018; Mutyaba et al., 2024). Biswas et al., (2019) noted that in Purulia district, most fish farmers relied on traditional, extensive aquaculture methods, with limited awareness of modern, semi-intensive techniques and scientific practices. Although some have basic literacy, their overall low knowledge hampers productivity and creates challenges in the aquaculture value chain. Considering these facts, the main objective of this study was to examine the present aquaculture practices and knowledge levels of respondents in the study area.

METHODOLOGY

The study was carried out in Purulia district, West Bengal, in the year 2024–25, which lay in the undulating red laterite zone where soil conditions were generally unsuitable for fish farming. Despite this, aquaculture emerged as an important economic activity, particularly in seasonal ponds. Two blocks, namely Baghmundi and Arsha, were purposively selected due to the notable presence of fish farmers practicing aquaculture. From each block, 60 respondents were chosen using a simple random sampling without replacement technique, making a total sample of 120 respondents. An ex-post facto research design was employed. Primary data were collected using a pre-tested semi-structured interview schedule, while secondary data were obtained from government records, websites, and research reports. The data were then tabulated and analyzed using appropriate statistical tools. Various dimensions of aquaculture practices were categorized after a pilot survey in line with the study's objectives, and responses were collected accordingly. The knowledge level of the respondents was evaluated using question statements, where a score of 1 was given for correct responses and 0 for incorrect ones, followed by a teacher-made test developed by Nagarajaiah (2002) with necessary modifications to suit the context. This knowledge test covered statements related to pre-stocking, stocking, and post-stocking practices. The total raw scores were then transformed into a knowledge index. Furthermore, respondents were classified into three categories based on the mean and standard deviation, namely: low (mean – SD/2), medium (between mean – SD/2 and mean + SD/2), and high (mean + SD/2) level of knowledge regarding fish farming.

$$\text{Knowledge index (KI)} = \frac{\text{Number of correct responses}}{\text{Total number of knowledge items}} \times 100$$

A set of constraints encountered by the respondents in the study area regarding aquaculture practices was gathered during the survey and ranked by employing the Rank-Based Quotient (RBQ) method.

$$RBQ = (\Sigma\ fi(n+1-i) / (N * n)) * 100$$

Where, fi: The frequency of respondents reporting a particular problem under the i^{th} rank. N: The total number of respondents, n: The total number of ranks (or constraints/ problems), i: The rank of the problem.

RESUTS

Present state of aquaculture practices

In Purulia, fish farming has recently gained prominence as farmers have begun to recognize its potential as a profitable livelihood. Consequently, they gradually began adopting the recommended scientific aquaculture practices, as presented in Table 1. Most of the ponds used by respondents were earthen (90.83%), and the majority were located 2 to 3 km away from their residences (56.67%). In terms of ownership, a large proportion of ponds were leased (74.17% of the total). The primary water source for these ponds was rainwater (68.33%), with long seasonal water retention (56.67%) being the most common source. The majority of respondents maintained rearing ponds (90.00%), while only a small percentage had combined nursery and rearing ponds (4.17% of respondents). The average pond depth was generally between 4 and 6 ft (56.17%). Only a few respondents practiced pond drying (5.83%), while the majority did not (94.17%). In addition, inlet and outlet systems were present in only 26.67% of the ponds. Apart from aquaculture, 76.67 per cent of the ponds were used for domestic purposes. Water quality testing was conducted daily (5.00%), weekly (14.17%), monthly (26.67%), and rarely (54.16%). Most respondents practiced polyculture or mixed farming (70.00%), with Indian major carp (*L. rohita, C. catla, C. mrigala*) and exotic carp (*H. molitrix, C. idella, C. carpio*) being the primary species stocked (86.67%). Notably, 69.17 per cent of farmers did not follow a fixed stocking density, and only a small proportion (6.67%) adopted a comprehensive input strategy involving stocking,

Table 1. Aquaculture practices in Purulia district

S.No.	Variable	Category	Percentage (%)
1	Pond Type	Earthen	90.83
		Concrete	9.17
2	Distance from Residence	1–2 km	22.50
		2–3 km	56.67
		3–4 km	15.83
		Above 4 km	5.00
3	Pond Ownership	Self-owned	25.83
		Leased	74.17
4	Main Water Source	Rainfed	68.33
		Canal/River	14.17
		Deep well	17.50
5	Water Retention	Short seasonal (3–6 months)	31.67
		Long seasonal (6–9 months)	56.67
		Perennial	11.66
6	Type of Pond	Nursery	-
		Rearing	90.0
		Grow-out	5.83
		Both (Nursery + Rearing)	4.17
7	Average Pond Depth	1 to 4 ft	16.17
		4 to 6 ft	56.17
		6 to 8 ft	26.16
8	Drying Ponds	Yes	5.83
		No	94.17
9	Inlet/Outlet System in pond	Yes	26.67
		No	73.33
10	Infested with Weeds	Yes	31.67
		No	68.33
11	Extent of Weed Infestation	Complete Choked	1.67
		Moderate	16.67
		Low	51.66
		Nil	30.00
12	Use of Water Body	Irrigation	13.33
		Domestic	76.67
		Both	10.00
13	Water Quality Test Frequency	Daily	5.00
		Weekly	14.17
		Monthly	26.67
		Rarely	54.16
14	Type of Culture Practice	Monoculture	4.16
		Composite	19.17
		Integrated	6.67
		Polyculture/Mix farming	70.00
15	Culture Input Level	Stocking only	13.33
		Stocking + Feeding	51.67
		Stocking + Manuring + Feeding	28.33
		Stocking + Manuring + Feeding + Liming	6.67
16	Species Stocked	Indian Major Carps (IMC), Exotic carps	86.67
		Mixed (IMC/exotic/ catfishes)	13.33
17	Stocking rate /stocking density	Fixed	30.83
		Not Fixed	69.17
18	Type of Manure Used	Organic	14.17
		Inorganic	65.83
		Both	20.00
19	Type of Feed Used	Natural	54.16
		Supplementary	30.83
		Commercial	15.00
20	Source of Fish Seed	Ramsagar Hatchery	95.0
		Naihati Hatchery	5.0
		Own	-
		Local Market	-

Table 1 contd...

S.No.	Variable	Category	Percentage (%)
21	Feeding Frequency	One time/day	22.50
		Two times/day	61.67
		Not fixed	15.83
22	Monitoring Growth	Yes	77.50
		No	22.50
23	Method of Harvesting	Partial	55.83
		Complete	9.17
		Need-based	35.00
24	Mode of Harvesting	Self	14.17
		Employing Labour	57.50
		Both	19.17
		Auction	9.16
25	Harvesting Time	Yearly 3–4 times	49.17
		Yearly 2–3 times	14.17
		Yearly 1–2 times	6.66
		Need-based	30.00
26	Mode of Disposal	Self-retailing	19.17
		Sold to Wholesaler	59.17
		Both	21.66
27	Marketing of produce	Local market	85.83
		Other areas in the district	14.17
		Export to another district	-
28	Preventive Disease Measures	Yes	75.83
29	Faced Major Disease Outbreak	Yes	65.00
30	Routine Health Management Program	Yes	76.67
31	Monitoring & Record Keeping	Yes	74.17

manuring, feeding, and liming. In terms of manure usage, most farmers relied on inorganic manure (65.83%). The feed types used included natural (54.16%), supplementary (30.83%), and commercial feed (15.00%). The primary source of fish seeds was the Ramsagar hatchery (95.00%). Feeding was typically done twice a day (61.67%), and 77.50 per cent of the respondents regularly monitored fish growth. Harvesting was mostly partial (55.83%), and the predominant method involved employing labour (57.50%). Fish were generally harvested three to four times annually (49.17%) or on a need-based schedule (30.00%). In terms of marketing, the produce was mainly sold to wholesalers (59.17%) and primarily in local markets (85.83%). Regarding health and disease management, 75.83 per cent of respondents took preventive measures, and 76.67 per cent followed a routine health management program. Finally, a good number of respondents (74.17%) maintained records and monitored their aquaculture activities.

Knowledge level

An assessment of the knowledge levels of fish farmers regarding recommended aquaculture practices categorized them into three groups: low, medium, and high. It was found that 38.33 per cent of respondents fell under the medium knowledge level, while 34.17 per cent had low knowledge level, and only 27.50 per cent exhibited a high level of understanding regarding fish farming.

To understand the influence of demographic characteristics on the knowledge level of fish farmers, chi-square tests and Cramer's V value estimation were done. The results are summarized in Table 2. Significant associations were found between some of demographic variables and the knowledge level of respondents in the study area (N = 120), as indicated by Pearson's χ^2 value. The variables age (χ^2 = 149.005*), education (χ^2 = 160.112*), farming area (χ^2 = 151.825*), occupation (χ^2 = 94.765*), social participation (χ^2 = 121.163*), annual income (χ^2 = 177.089*), farming experience (χ^2 = 199.751*), mass media exposure (χ^2 = 145.832*), extension agency contact (χ^2 = 162.137*), economic motivation (χ^2 =

Table 2. Relationship between demographic variables and knowledge level of the respondents

S.No.	Variables	Pearson Value Chi-square (χ^2)	Cramer's V value
1	Age	149.005*	0.761
2	Caste	101.205NS	—
3	Education	160.112*	0.817
4	Family Size	92.761**	0.675
5	Type of House	101.852**	0.693
6	Farming Area	151.825NS	—
7	Occupation	94.765*	0.889
8	Social Participation	121.163*	0.715
9	Annual Income	177.089*	0.657
10	Farming Experience	199.751*	0.912
11	Mass Media Exposure	145.832*	0.858
12	Extension agency Contact	162.137*	0.935
13	Economic Motivation	186.595*	0.832
14	Risk Orientation	176.708*	0.857

*Significant at 0.01 level of probability; **Significant at 0.05 level of probability; NS = Non-Significant

Table 3. Major constraints encountered by the respondents for fish farming

S.No.	Statement	RBQ value	Rank	Constraints category
1	Inadequate technical support for scientific farming	86.09	I	Technical
2	High cost of input materials and labour	85.4	II	Economic
3	Getting less selling price for the produce	84.98	III	Marketing
4	Lack of access to market channels and involvement of middlemen	83.94	IV	Marketing
5	Lack of access to quality inputs	83.17	V	Technical
6	Inadequate infrastructure and resources	79.4	VI	Technical
7	Financial burden and high-interest rate of the local moneylender	78.73	VII	Economic
8	Lack of support from the government	72.49	VIII	Economic
9	Lack of adequate extension support, like a need-based training program	67.89	IX	Extension service
10	Water scarcity in the area	64.68	X	Environmental

186.595*), risk orientation (χ^2 = 176.708*) showed significant associations at a probability level of 0.01. Family size (χ^2 = 92.761**) and type of house (χ^2 = 101.852**) showed significant associations at a probability level of 0.05. While also estimation of Cramer's V value in chi-statistics (Lee, 2016), it is also pointed out that education, occupation, farming experience, mass media exposure, extension agency contact, source of information, economic motivation, risk orientation all these variables have the very strong (Cramer's V 0.80–1.00) relationship with knowledge level of respondents.

Constraints encountered by the respondents

Several constraints were encountered by the respondents in the study area in various dimensions related to profitable farming, among those some important constraints were ranked and listed as per the responses and presented in Table 3. The most critical constraint faced by fish farmers was the inadequate technical support for scientific farming (RBQ: 86.09), followed by the high cost of input materials and labour (RBQ: 85.40), getting less selling price for the produce (RBQ: 84.98), lack of access to market channels and the involvement of middlemen (RBQ: 83.94), lack of access to quality inputs ranked high among the challenges (RBQ: 83.17).

DISCUSSION

Education plays a key role in improving farm decision-making, yet most respondents possess only up to 8th standard education, highlighting the need to motivate the younger generation (Biswas et al., 2019; Unnikrishnan & Dinesh, 2020). As most respondents were marginal, diversifying income sources is essential (Majhi, 2018). Low training exposure further limits scientific knowledge transfer, leading farmers to rely on traditional practices (Mondal et al., 2025), emphasizing the urgent need for targeted motivation and mentorship. Despite challenging conditions, fish farming is growing, but most farmers still rely on traditional, unscientific methods, limiting productivity, consistent with findings by Biswas et al., (2019). Scientific aquaculture promotes practices like pond drying, proper stocking density, organic manure use, balanced feeding, fish health, and water quality monitoring (Kumar et al., 2018; CMFRI, 2020). However, the study shows major gaps, least percentage practiced pond drying (Biswas et al., 2019). The majority of respondents did not follow proper stocking ratio rather optimal stocking densities to ensure uniform growth and efficient feed conversion (Fatima et al., 2020). Only few adopted comprehensive input strategies that combine stocking, manuring, feeding, and liming, despite this being a foundational element of semi-intensive aquaculture systems (Kalidoss, 2024). Given the widespread presence of animal husbandry in the region (ARD, Purulia, 2022), promoting the use of organic or mixed manure is essential, as most respondents still rely solely on inorganic inputs, reducing their net profit. Additionally, regular fish health monitoring should be a universal practice, yet it remains neglected in the area, highlighting the need to strongly encourage its adoption. Water quality management is weak, as over half the respondents rarely test their pond water. Scientific guidelines suggest monthly checks for dissolved oxygen, pH, and ammonia (Kumar et al., 2018; Moses, 2023). Without regular monitoring, farmers often detect issues only after fish health declines. Ragasa et al., (2022) reported that connecting farmers with multiple certified hatcheries enhances seed quality and reduces over-dependence. Therefore, addressing this issue is crucial for improving aquaculture production in the region. Most of the respondents in the area had low to medium knowledge regarding recommended aquaculture practices. There was a clear gap in both understanding and application, mainly due to limited access to technical training, extension services, and hands-on demonstrations (Biswas et al., 2019). The study finds that extension agency contact has the strongest relationship with knowledge level, reinforcing earlier findings by Jarh et al., (2024) & Sarkar et al., (2021) that targeted extension can significantly influence adoption of best management practices (BMPs). The study identifies several key constraints limiting profitable aquaculture in Purulia. To address these, strategic actions are needed—primarily, enhancing field-level extension services through regular farm visits, on-site demonstrations, and community-based aquaculture advisors to tackle the major issue of inadequate technical support (RBQ: 86.09) (Biswas et al., 2019; Kappen, 2018). Promoting local production of feed and encouraging group purchases, can help overcome challenges related to input quality and middlemen. Additionally, ensuring the timely availability of quality seed, feed, and fertilizers (RBQ: 83.17) by linking farmers with certified suppliers, along with promoting financial literacy, is essential for strengthening input access and resource planning (Dutta et al., 2022). To bridge the practice gap, a concerted educational effort is needed to promote standardized practices, deliver hands-on training, and provide farmers with access to quality inputs and market linkages (Mondal

et al., 2025; Olaganathan & Kar, 2017). Without this support, the potential of aquaculture to transform rural livelihoods in Purulia will remain underrealized, despite its growing relevance in the region.

CONCLUSION

This study establishes that aquaculture in Purulia holds significant potential but is hindered by limited knowledge and suboptimal adoption of scientific practices among farmers. Most fish farmers operate seasonal, rain-fed ponds and rely heavily on traditional methods due to insufficient training, weak extension services, and high input costs. The strong correlation between knowledge level and factors like education, extension contact, and farming experience confirms that targeted support mechanisms are essential. These findings highlight the urgency of implementing structured training, localized extension systems, and input accessibility to enable farmers to improve productivity and sustainability. The results confirm the hypothesis that knowledge gaps, if addressed strategically, can unlock aquaculture's potential as a reliable livelihood in this underdeveloped region. Policymakers should prioritize inclusive, farmer-centric programs to support the adoption of best practices, empower marginal communities, and ensure long-term development of the sector.

Data availability statement: The corresponding author has access to the study's raw data.

Author's contribution: Conceptualization and designing of the research work (N.R.; A.H.M., S.S.D.); Execution of field/lab experiments and data collection (N.R.; A.H.M.); Analysis of data and interpretation (N.R.; A.H.M., R.K.); Preparation of manuscript (A.A.; D.R.; A.H.M., M.R.S.).

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Research Article

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Predictive Role of Cyberbullying and Victimization on General Psychological Distress among PhD Students

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HIGHLIGHTS

- Cyberbullying and cyber victimization significantly positively predict general psychological distress among PhD students, after controlling for demographic variables.
- Cyber victimization strongly predicted anxiety, while cyberbullying was more linked to depression, highlighting the distinct effects on emotional well-being.
- Hierarchical stepwise regression analysis verified that cyberbullying uniquely contributed to each DASS-21 subscale and the general psychological distress.

ARTICLE INFO

Keywords: Online aggression, Psychological distress, PhD students, Hierarchical regression, Mental health, Higher education.

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ABSTRACT

The study examines the predictive impact of cyberbullying and cyber victimization on general psychological distress (stress, anxiety, and depression) among PhD students. A total of 250 doctoral participants in 2025 (male = 122, female = 128, age mean = 28.02, standard deviation = 2.66) from Banaras Hindu University and Aligarh Muslim University were assessed. A self-prepared demographic survey, Cyber-Bullying and Cyber-Victimization Experience Questionnaire (CBVEQ-E α = .89) and depression, anxiety, and stress scale-21 (DASS-21.89) were used for the purpose. Hierarchical stepwise regression analysis was employed and revealed that cyberbullying significantly positively predicted higher levels of stress (β = 0.236, $p < .001$), anxiety (β = 0.261, $p < .001$), depression (β = 0.260, $p < .001$), explaining 5 to 6.3% of the variance in individual general psychological distress dimensions. Cyberbullying also emerged as a significant predictor of general psychological distress (β = 0.280, $p < .001$), contributing 7.1 per cent of the variance. These findings underscore the adverse effects of cyberbullying on the mental health of doctoral students due to high-pressure academic environments. The study emphasizes the need for mental health interventions, institutional support systems, and anti-bullying policies to mitigate the negative impact of cyberbullying in academic settings.

INTRODUCTION

The increasing prevalence of digital communication has transformed academic environments, achievement motivation, encouragement, empowerment, and extension services for more impactful outcomes (Nain et al., 2019; Yadav & Dube, 2025). However, it has also presented opportunities for negative interactions, such as cyberbullying and social media addiction using artificial intelligence and machine learning (Smith et al., 2008; Khanganbi & Priya, 2024). Cyberbullying, defined as deliberate and repeated aggressive behaviors through the use of electronic devices (Hinduja & Patchin, 2014), has emerged as a significant

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psychological consequence among university students. Cyber victimization is defined as the experiences and psychological impacts faced by individuals targeted by such online aggression. The doctoral life, characterized by stress, rigorous coursework, high research expectations, intense workload, social isolation, and financial burdens, may be vulnerable to the detrimental effects of cyberbullying on mental health in academic settings (Campbell et al., 2013; Kowalski et al., 2024).

Previous research consistently demonstrated a significant association between cyberbullying and stress, anxiety, and depression symptoms in adolescent undergraduates and young adult populations (Moore et al., 2021; Nixon, 2024). Experience of digital harassment, whether as a perpetrator (cyberbullying) or a target (cyber victimization), has been associated with increased levels of general psychological distress (Tokunaga, 2010; John et al., 2018). The widespread reach of the internet can exacerbate psychological distress, leading to feelings of hypervigilance, helplessness, sleep disturbances, low self-esteem, and social isolation among victims (Beren & Li, 2007). However, limited studies have focused on doctoral students, who face various stressors such as publication pressure, prolonged periods of isolation, and financial instability (Levecque et al., 2017). These stressors make it mandatory to examine the population specifically. From the perspective of form and context, younger populations typically face peer-based cyberbullying (Aoyama, Barnard-Brak, & Talbert, 2013), and doctoral students may be subjected to cyber victimization in academic and semi-professional contexts (Phelps et al., 2021).

The depression, anxiety, and stress scale (DASS-21), a well-validated measure, has been widely used to measure general psychological distress in academic settings (Lovibond & Lovibond, 1995; Antony et al., 1998). It's confirmed the capability of capturing depression, anxiety, and stress symptoms across diverse populations by previous studies (Antony et al., 1998; Henry & Crawford, 2005). Previous studies have shown a link between cyber victimization and increased symptoms of depression, which is mediated by low self-esteem and social isolation (Campbell et al., 2013). Previous research also utilized this scale and has shown strong associations between cyberbullying experiences and increased levels of depression, anxiety, and stress (Tokunga, 2010; John et al., 2018).

This study aimed to assess the predictive role of cyberbullying on stress, anxiety, depression, and general psychological distress among PhD students. Based on prior research, we hypothesized that cyberbullying would significantly positively predict increased levels of general psychological distress, with cyber victimization being particularly associated with anxiety, and overall cyberbullying contributing to depression and stress. The findings aim to contribute empirical evidence on the consequences of cyberbullying in PhD education, informing educational institutional policies to mitigate its adverse effects.

METHODOLOGY

The current study involved 250 PhD students; male students (n = 122, 48.8%) and females (n = 128, 51.2%) aged between 22 and 36 years (M = 28.02, SD = 2.66. There are two major variables, namely cyberbullying (predictor variable) and DASS, generally called general psychological distress (criterion variable), and demographic variables (controlled variables). A self-prepared survey featuring demographic questions, a reliable, validated cyber-bullying and cyber-victimization experience questionnaire, and a DASS-21 questionnaire was used to measure responses. A total sample of PhD students was selected by a convenient sampling technique from the Banaras Hindu University, Varanasi, and Aligarh Muslim University, Aligarh, in Uttar Pradesh.

Cyber-bullying and cyber-victimization experience questionnaire (CBVEQ) developed by Antoniadou et al., (2016) assesses the occurrence of direct and indirect CB/CV behaviours. It has a 5-point frequency scale ranging from 1 (Never) to 5 (Every Day), measuring samples. It consists of 24 items with two parts, i.e., 12 items for cyberbullying and 12 for cyber victimization, on a 5-point frequency scale ranging from 1 (Never) to 5 (Every Day). The Cronbach coefficient for the cyberbullying in this sample was determined to be .89, for the total amount of cyberbullying.

To measure levels of general psychological distress, the stress, anxiety, and depression (DASS-21) scale was used due to their recent validation studies. The DASS-21 items are a short-form version of the original 42-item scale developed by Lovibond and Lovibond (1995). It is divided equally into three subscales, and each item is scored on a 4-point Likert scale, ranging from 0 (Did not apply to me at all) to 3 (Applied to me very much or most of the time). The DASS-21 has been shown to have good internal consistency in this sample (α= .89) (Antony et al., 1998; Lovibond & Lovibond, 1995).

The purpose of this study was to assess the relative significance of cyberbullying, cyber victimization, and cyberbullying in general for PhD students at universities. The researcher built rapport with PhD students and used straightforward, secure, and effective methods to perform this study in order to get better responses. All participants gave their consent before data were collected, and they were then given the right instructions on how to complete the questionnaire. The questionnaire is solely used for this study, and all answers are kept confidential. The data were statistically examined using hierarchical step-wise regression analysis, and scoring was completed following the handbook Andy Field's (2008) recommendations.

RESULTS

According to SPSS output, the following table summarises the findings of the hierarchical stepwise regression analysis:

In hierarchical stepwise regression analysis, demographic variables (age, gender, marital status, family type, family status, religion, and category) were entered in the first step, and all the dimensions of cyberbullying were entered in the second step. It is visible from the results presented in Table 1 that cyberbullying overall emerged as a significant predictor of DASS-Stress of the PhD students. Table values reveal that cyberbullying overall was found to be significantly positively associated with DASS-Stress (β=.236, p<.001) of the PhD students, and it explains 5.0% of the total variance in explaining DASS-Stress.

In hierarchical stepwise regression analysis, demographic variables (age, gender, marital status, family type, family status, religion, and category) were entered in the first step, and all the

dimensions of cyberbullying were entered in the second step. It is visible from the results presented in Table 2 that cyber victim emerged as a significant predictor of DASS-Anxiety of the PhD students. Table values reveal that cyber victim was found to be significantly positively associated with DASS-Anxiety (β=.261, p<.001) of the PhD students, and it explains 6.3 per cent of the total variance in explaining DASS-Anxiety.

Table 1. Summary of hierarchical stepwise regression analysis for cyberbullying, DASS-stress, and demographics

Model	Variables	DASS-Stress	
		Step 1	Step 2
Simultaneous regression (Step1)	Demographic variables (Control Variables)	Beta *(β)*	Beta *(β)*
	Age	-.039	-.044
	Gender	.165	.237
	Marital Status	-.079	-.065
	Family Type	.100	.090
	Family Status	-.037	.003
	Religion	.057	.072
	Category	-.009	-.012
Dimensions of Cyberbullying (Cyberbullying, Cyber Victim, and Cyberbullying Overall) as predictor variables			
Stepwise regression (Step2)	Cyberbullying overall		.236***
R		.261	.344
R^2		.068	.118
R^2 *change*		.068	.050
F change		2.522*	116.986***

a- Step 1 degree of freedom= 7, 242; Step 2 degree of freedom = 1, 241
**p<.05, ***p<.001*

Table 2. Summary of hierarchical stepwise regression analysis for cyberbullying, DASS-anxiety, and demographics

Model	Variables	DASS-Anxiety	
		Step 1	Step 2
Simultaneous regression	Demographic variables (Control Variables)	Beta *(β)*	Beta *(β)*
	Age	-.048	-.036
(Step1)	Gender	.060	.138
	Marital Status	-.083	-.069
	Family Type	.067	.059
	Family Status	-.021	.017
	Religion	.035	.039
	Category	-.029	-.036
Dimensions of Cyberbullying (Cyberbullying, Cyber Victim, and Cyberbullying Overall) as predictor variables			
Stepwise regression (Step2)	Cyber victim		.261***
R		.155	.295
R^2		.024	.087
R^2 *change*		.024	.063
F change		.846	16.591***

a- Step 1 degree of freedom= 7, 242; Step 2 degree of freedom = 1, 241
****p<.001*

Table 3. Summary of hierarchical stepwise regression analysis for cyberbullying, DASS-depression, and demographics

Model	Variables	DASS-Depression	
		Step 1	Step 2
Simultaneous regression (Step1)	Demographic variables (Control Variables)	Beta *(β)*	Beta *(β)*
	Age	-.037	-.064
	Gender	.048	.110
	Marital Status	-.106	-.093
	Family Type	.055	.044
	Family Status	-.066	-.025
	Religion	.086	.115
	Category	-.016	-.014
Dimensions of cyberbullying (Cyberbullying, Cyber Victim, and Cyberbullying Overall) as predictor variables			
Stepwise regression (Step2)	Cyber bullying		.260***
R		.182	.308
R^2		.033	.095
R^2 *change*		.033	.062
F change		1.189	16.385***

a- Step 1 degree of freedom= 7, 242; Step 2 degree of freedom = 1, 241
****p<.001*

In hierarchical stepwise regression analysis, demographic variables (age, gender, marital status, family type, family status, religion, and category) were entered in the first step, and all the dimensions of cyberbullying were entered in the second step. It is visible from the results presented in Table 3 that cyberbullying emerged as a significant predictor of DASS-Depression of the PhD students. Table values reveal that cyber bullying was found to be significantly positively associated with DASS-Depression (β=.260, p<.001) of the PhD students, and it explains 6.2% of the total variance in explaining DASS-Depression.

In hierarchical stepwise regression analysis, demographic variables (age, gender, marital status, family type, family status, religion, and category) were entered in the first step, and all the dimensions of cyberbullying were entered in the second step. It is visible from the results presented in Table 4 that cyberbullying overall emerged as a significant predictor of DASS-Overall of the PhD students. Table values reveal that cyberbullying overall was found to be significantly positively associated with DASS-Overall (β=.280, p<.001) of the PhD students, and it explains 7.1 per cent of the total variance in explaining DASS-Overall.

DISCUSSION

The findings revealed that cyberbullying significantly contributes to general psychological distress and its dimensions. These findings underscore the detrimental psychosomatic effects of cyberbullying, which acts as an additional significant psychological stressor in the academic setting. The social isolation nature of doctoral programs, PhD students facing cyberbullying can experience severe hopelessness, low self-worth, and limited peer support, which further amplifies to increased risk of depression (Campbell et al., 2013).

Table 4. Summary of hierarchical stepwise regression analysis for cyberbullying, DASS-overall, and demographics

Model	Variables	DASS-Overall	
		Step 1	Step 2
Simultaneous regression (Step1)	Demographic variables (Control Variables)	Beta *(β)*	Beta *(β)*
	Age	-.047	-.052
	Gender	.101	.187
	Marital Status	-.101	-.085
	Family Type	.083	.071
	Family Status	-.048	.000
	Religion	.068	.086
	Category	-.020	-.024
Dimensions of cyberbullying (Cyberbullying, Cyber Victim, and Cyberbullying Overall) as predictor variables			
Stepwise regression (Step2)	Cyberbullying overall		.280***
R		.217	.344
R^2		.047	.118
R^2 *change*		.047	.071
F change		1.708	19.380***

a- Step 1 degree of freedom= 7, 242; Step 2 degree of freedom = 1, 241
****p<.001*

In the first regression model, demonstrated that overall cyberbullying was a significant positive predictor of DASS-stress levels (b= 0.236, p < .001), explaining an additional 5% of the variance beyond demographic variables. These output supports and verify previous research indicating that online harassment can elicit chronic psychological stress, particularly in high-pressure academic settings (Kowalski et al., 2024). The doctoral students often face intense workload, uncertainty, high performance expectations, and publication pressure, which may amplify the negative impact of cyberbullying behaviours. It's the limitation of this study that constantly connecting to social media can contribute to distress. Future research may use a multivariate approach that includes these context-specific variables to better understand their relative and combined effects. Similarly, the dimension of cyberbullying named cyber victimization emerged as a significant predictor of anxiety levels (β=0.261, p< .001), accounting for 6.3 per cent of the variance in DASS-anxiety scores among PhD students. These findings align with studies showing that victims of cyber aggression often experience heightened anxiety symptoms due to the unpredictable and pervasive nature of online harassment (Nixon, 2024). Currently demanding nature of digital communication in academic and professional settings, these findings is noteworthy. Cyber victimization can occur persistently at any time and in multiple digital spaces, which are linked with exacerbating anxiety-related symptoms, hypervigilance, sleep disturbances, and feelings of helplessness (Beren & Li, 2007). Those PhD students, whose professional reputation is closely tied to online, may lead to chronic anxiety about their career, future victimization, and public shaming. These findings are consistent supports studies that have a strong link between cyber victimization and anxiety in adolescents and young adults (Moore et al., 2021), suggesting a similar dynamic may be at play among PhD students.

The strongest significant positive association was found between cyberbullying and depression (β=0.260, p< .001), explaining 6.2 per cent of the variance in DASS-depression scores. These findings are consistent with previous meta-analytic evidence that highlights the link between cyber victimization to depressive symptoms among PhD students (John et al., 2018). Cyberbullying or the potential of online aggression can lead to feelings of isolation, low self-esteem, and a sense of worthlessness, which are core clinical pictures of depression (Tokunaga, 2010). Importantly, the study also measured the cumulative impact of cyberbullying on general psychological distress (DASS-overall), and cyberbullying again emerged as a significant positive prediction (β= .280, p< .001), contributing to 7.1 per cent of the variance in general psychological distress. These findings indicate and provide a comprehensive picture of the negative impact of cyberbullying on the general mental health of PhD students. It is important to note that the variance contributed by cyberbullying in each subscale of DASS and overall score is statistically positively significant it representing a moderate proportion of the total variance. These findings suggest that cyberbullying plays a crucial role in predicting mental health outcomes; other factors, such as academic pressure, financial concerns, social support, and individual coping mechanisms, also contribute significantly to the stress, anxiety, depression, and general psychological distress experienced by doctoral students.

CONCLUSION

The study robustly demonstrates the significant predictive role of cyberbullying and cyber victimization experience on general psychological distress (stress, anxiety, and depression) among PhD students beyond demographic factors. Hierarchical stepwise regression analysis exhibited that cyberbullying uniquely and significantly predicted and additionally accounted for all dimensions of general psychological distress. The strongest associations were found that cyber victimization emerged as a key predictor of anxiety, while cyberbullying emerged as a significant predictor of depression, underscoring the profound emotional and psychosomatic toll of online aggression in academic settings. Furthermore, cyberbullying overall significantly contributed to general psychological distress. These findings contributed to prior research, suggesting that the persistent and invasive nature of cyberbullying and the cyber victim experience exacerbate mental health issues due to a socially isolating and high-pressure academic environment in doctoral students. These results emphasize the critical need for targeted interventions and institutional policies to mitigate cyberbullying in academia.

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Research Article

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Agricultural Productivity through Rural Assets: Evaluating MGNREGA's Role in Boosting Agricultural Performance in India

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HIGHLIGHTS

- MGNREGA infrastructure projects significantly improve agricultural yield, cultivated area, and total production across Indian states.
- Employment generation under MGNREGA positively influences agricultural productivity through increased labour availability and infrastructure use.
- Land development and micro-irrigation interventions show strong positive associations with crop productivity and farm expansion.

ARTICLE INFO

Keywords: Agricultural productivity, MGNREGA, Rural public infrastructure, Random-fixed effect, Agricultural extension.

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ABSTRACT

The study evaluated the agricultural productivity effects of rural infrastructure investments and employment provision under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) in India. The study assesses how public works, such as land development, micro-irrigation, drought-proofing, and rural connectivity, support key agricultural outcomes, including cultivated area, crop yield, and total production. Using state-level panel data from 2016 to 2023 and applying both fixed and random effects models, the study rigorously accounts for state-specific heterogeneity and time-invariant factors, ensuring unbiased and policy-relevant estimates of MGNREGA's impact on agriculture. The empirical findings demonstrate robust positive effects of MGNREGA-facilitated assets, particularly land development, drought-proofing, water conservation, and micro-irrigation, on key agricultural performance indicators. Notably, localised employment generation, as indicated by person-days of employment, emerges as a critical enabler of enhanced productivity. These findings highlight the potential of MGNREGA not merely as a welfare initiative but as a catalytic policy tool for agricultural enhancement. The research underscores the value of integrating rural employment schemes with agronomic needs to improve productivity, stabilise output, and support sustainable rural livelihoods in India's agrarian economies.

INTRODUCTION

Agriculture remains the backbone of the Indian economy, employing approximately 46.1 per cent of the workforce as of 2023–24 and contributing 15.998 per cent to the nation's Gross Value Added (GoI, 2024). Despite its centrality, the sector faces persistent structural challenges, including low productivity, inadequate irrigation, limited land development, and exposure to climate-related risks (Shaba & Alam, 2024). The MGNREGA, enacted in 2005, is India's flagship social protection program that guarantees 100 days of wage employment annually to rural households (Mohanakumar & Vipin Kumar, 2018). Its primary aim is to provide wage employment and enhance livelihood security, literature highlights its potential in creating durable rural assets that improve the productive capacity of land and labour (Drèze & Khera, 2017). In 2023–24, MGNREGA registered 26.17 crore workers,

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with 11.81 crore active participants. The scheme generated 308.66 crore person-days across 5.99 crore households, with 58.9 per cent of labour contributed by women, reflecting strong gender inclusion. On the infrastructure front, 220.44 lakh works were undertaken, comprising 136.19 lakh ongoing and 84.25 lakh completed projects (MoRD, 2024). Over 45 per cent of total expenditure was directed towards agriculture and allied activities, reinforcing the scheme's developmental alignment with rural livelihoods (MoRD, 2024).

Existing studies focus on the program's impact on income security (Sheahan et al., 2018), women empowerment (Rodriguez, 2022), poverty alleviation (Patel, 2024), and labour market outcomes (Imbert & Papp, 2015), with fewer attempts to rigorously evaluate its role in enhancing agricultural performance. Some localised assessments suggest that MGNREGA can improve groundwater recharge, reduce soil erosion, and enhance cropping intensity (Shah, 2016; Reddy & Babu, 2018), but these findings are often context-specific and lack generalisability. There is thus a need to systematically assess whether MGNREGA functions as a productive complement to agriculture at a macro level. Present study draws upon the Agricultural Production Function framework, a classical model in agricultural economics that posits that output is a function of multiple inputs, including land, labour, capital, and technology (Gautam, 2024). Public infrastructure created under MGNREGA is theorised to augment these inputs by enhancing the efficiency and productivity of the natural resource base, improving access to water, facilitating timely labour supply, and reducing input-output transaction costs (Anantha et al., 2021). In doing so, these interventions are not merely welfare measures but constitute indirect public investments in agriculture that potentially alter production frontiers, especially in marginal and resource-constrained areas. Within this theoretical framework, the paper hypothesises that MGNREGA-related infrastructure and labour mobilisation positively affect crop yield, production, and area under cultivation. The analysis utilises state-level panel data spanning from 2016 to 2023 and employs fixed effects and random effects models to account for time-invariant heterogeneity and endogeneity concerns. In bridging employment policy and agricultural performance, this research contributes to an evolving discourse on the multifunctional role of public employment schemes in agrarian economies. It extends the literature by empirically validating the hypothesis that MGNREGA's asset-oriented interventions serve as productive complements to agricultural inputs, thereby enhancing output and efficiency and affirms that state-mediated labour mobilisation and infrastructural provisioning can operate as effective instruments of agrarian transformation in the Global South.

METHODOLOGY

This study employs a quantitative panel data approach to examine the effect of rural public infrastructure and employment generated under MGNREGA on agricultural performance in India. The dependent variables include three core indicators of agricultural output: crop yield (in kg/ha), production (in lakh tonnes), and area under cultivation (in lakh hectares), while the explanatory variables are derived from MGNREGA interventions related to employment and asset creation.

The panel dataset spans eight years (2016–2023) and includes state-level observations across 34 Indian states and UTs. Agricultural statistics, yield, production, and area are obtained from the Ministry of Agriculture & Farmers Welfare (UPAg, 2024), while MGNREGA indicators are sourced from the Ministry of Rural Development's Management Information System (MIS) (MoRD, 2024). The data are structured in a balanced panel format to enable consistent comparisons across time and states.

The key independent variables include MGNREGA employment metrics like Total workers employed (Total.Workers), total person-days generated (Person_employ), and wage expenditure (Wage_exp). Similarly, Rural asset indicators like Rural drinking water (Ruraldrinkingwater), rural sanitation works (RuralSanit), drought-proofing structures (Drought_Proof), land development works (LandDeve), micro-irrigation facilities (MicroIrrig), flood control (FloodControl), water conservation assets (WaterConservation), rural road connectivity (RuralConnect), rural infrastructure projects (Rural_Infra), and works executed on individuals' land (Works.on.Individuals.Land).

The empirical strategy adopts a panel regression model using both fixed effects (FE) and random effects (RE) estimators to account for heterogeneity across states (Dettori et al., 2022). The fixed effects model controls for time-invariant, unobserved heterogeneity by allowing each state to have its intercept, thereby isolating the within-state variation over time. The random effects model assumes that state-specific effects are uncorrelated with the explanatory variables and thus estimates both within- and between-state effects. The general panel regression model is specified as:

$$Y_{it} = \alpha+\beta_1 ActiveSC_{it} + \beta_2\ ActiveST_{it} + \beta_3\ ActiveOther_{it} + \beta_4\ ActiveWomen_{it} + \beta_5\ Wage\_exp_{it} + \beta_6\ Admin\_exp_{it} + \beta_7\ Person\_employ_{it} + \beta_8\ AvPDHH_{it} + \beta_9\ AvWagePD_{it} + \beta_{10}\ CostPerPD_{it} + \beta_{11}\ NRM\_Work_{it} + \beta_{12}\ VulSectwork_{it} + \beta_{13}\ Rural\_Infra\_cat_{it} + \upsilon_i + \lambda_t + \varepsilon_{it}$$

Where Y_{it} Agricultural outcome (Yield, Production, or Area), α Intercept term, β Vector of coefficients, X_{it} Vector of explanatory variables representing MGNREGA-related inputs, υ_i Unobserved time-invariant state-specific effects, λ_t, fixed effects, ε_{it} Idiosyncratic error term.

The Random Effects model assumes no correlation between these unobserved effects and the regressors, allowing for greater efficiency if the assumption holds.

$$Y_{it} = \alpha + \beta X_{it} + \upsilon_{it} + \varepsilon_{it}$$

The Fixed Effects model is particularly useful in controlling for state-specific factors such as institutional capacity, historical labour trends, or geographic characteristics that do not change over time.

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_{it}$$

This transformation removes υ_{it}, capturing only the within-state variation over time. The FE model is preferred when these unobserved effects are correlated with the regressors, i.e., $Cov(X_{it}, \upsilon_{it}) \neq 0$.

To empirically determine the appropriate specification for each dependent variable, the Hausman test is conducted (Vogelsang, 2012). Robust standard errors clustered at the state level are used to correct for heteroskedasticity and serial correlation. Before model

estimation, Variance Inflation Factors (VIFs) are computed to detect multicollinearity, and residual diagnostics are conducted to assess model validity. This rigorous econometric design facilitates a theoretically grounded and policy-relevant evaluation of how MGNREGA's labour-based asset creation influences the trajectory of agricultural development in India.

RESULTS

Econometric specifications: descriptive analysis, stationarity, and model selection

Descriptive statistics (Table 1) reveal substantial variation across states and years in both agricultural outcomes and MGNREGA-related variables, indicating heterogeneity in program implementation and agrarian contexts. High dispersion in variables like wage expenditure, person-days of employment, and infrastructure creation suggests differing state capacities and policy priorities. To ensure robustness of the analysis, the dataset was cleaned and standardised, with key variables like person_employ, wage_exp log-transformed to address skewness and facilitate elasticity-based interpretations. Overall, the descriptive summary underscores the importance of controlling for unobserved heterogeneity through panel models, given the diverse socio-economic and institutional landscapes influencing agricultural productivity across India.

To ensure the robustness of the panel data regression models and to mitigate the risk of spurious results, in Table 2, the Levin-Lin-Chu (LLC) unit root test was applied to assess the stationarity of the dependent variables: Area, Yield, and Production. The findings indicate mixed integration orders across the variables. The Area variable was found to be non-stationary in levels (LLC test statistic = 10.009, p = 0.8434), but became stationary after first differencing (LLC = –3.427, p = 0.0212), suggesting it is integrated of order one, I(1). In contrast, Yield and Production both demonstrated stationarity in level form, with statistically significant LLC test results (Yield: –2.123, p = 0.0128; Production: –6.824, p = 0.0044), thus confirming their status as I(0) series. Consequently, the regression models used first-differenced values for the Area variable, while Yield and Production were modelled in levels. Independent variables were not subjected to unit root testing due to the short panel structure and model specification.

To determine the most appropriate estimation technique for the panel data, Diagnostic tests for RE and FE models were estimated for each of the agricultural outcomes—cultivated area, yield, and production in Table 3. Model selection was guided by the Hausman specification test, which tests the null hypothesis that the preferred model is Random Effects, under the assumption that the individual-specific effects are uncorrelated with the regressors (Baltagi, 2014).

The Hausman test results (Area: p = 0.2855; Yield: p = 0.9819; Production: p = 0.2570) consistently suggest that the RE model is more suitable than the FE model for all three outcomes. This implies that unobserved state-level characteristics influencing agricultural performance are not systematically correlated with MGNREGA-related explanatory variables, allowing for more efficient estimation using RE.

Table 1. Descriptive statistics of the data

Variable	N	Mean	SD	Median	Min	Max
Area	231	21.72	25.75	17.35	0	101.17
Yield	231	2212.7	750.94	2099	0	4489
Production	231	45.15	49.98	34.89	0	212.5
Total.Workers	231	40.56	41.85	15.34	0.07	133.11
Wage_exp	231	184626.29	217613.27	81950.69	0	1057014.95
Person_employ	231	2672559.23	2998475.85	1018627	0	11826053
Rural_Infra	231	3007.35	9367.45	457	0	109305
Drought_Proof	231	10392.35	20138.68	2403	0	137906
FloodControl	231	3384.79	7817.99	648	0	60233
LandDeve	231	11368.14	30626.44	3539	0	323013
MicroIrrig	231	6883.34	15661.86	2532	0	166297
Ruraldrinkingwater	231	3116.66	5259.15	836	0	50313
RuralConnect	231	11381.46	16001.19	5225	0	91252
RuralSanit	231	11674.62	32086.32	1370	0	235426
WaterConservation	231	13617.78	20490.3	5528	0	131354
Works.on.Individuals.Land	231	177216.46	251266.58	38449	0	1158337

Source: Author's calculation

Table 2. Result for Levin-Lin-Chu (LLC) test for panel unit roots

Variable	LLC Test Statistic (Level) I/0	P value	LLC Test Statistic (1st Diff) I/1	P value	Integration Order
Area	10.009	0.8434	-3.427***	0.0212	I(1)
Yield	11.574***	0.6785	-2.123***	0.0128	I(0)
Production	-6.824***	0.0044	-7.345***	0.0032	I(0)

Source: Author's calculation

The Breusch–Pagan LM test confirms significant panel-level effects across all models ($p < 0.05$), reinforcing the use of panel estimation techniques over pooled OLS. This aligns with expectations, as state-level differences, such as agroclimatic conditions or administrative efficiency, are likely to influence agricultural trends over time. However, the Wooldridge test for autocorrelation indicates the presence of first-order serial correlation in all three models. This suggests that agrarian performance in one year is influenced by prior-year conditions, such as residual impacts of infrastructure or monsoon variability. Likewise, the Pesaran CD test reveals cross-sectional dependence, meaning that agricultural outcomes in one state are influenced by developments in others–an expected trend in a federal system with shared policies and interlinked resource flows. Finally, the Mean VIF values (Area: 4.157; Yield: 4.267; Production: 4.012) suggest no major multicollinearity, validating the stability of regression coefficients.

These diagnostics highlight two important trends. First, agricultural outcomes are not isolated across time or geography, underscoring the systemic nature of agrarian development. Second, given these violations of standard FE model assumptions, the standard errors were corrected using Driscoll-Kraay robust standard errors (Vogelsang, 2012). This method accounts for heteroscedasticity, serial correlation, and cross-sectional dependence, which are likely in macro-panel data such as the one used in this study. The estimation was conducted using the vcovSCC function from the plm package in R, which implements Driscoll-Kraay standard errors with a fixed number of lags suitable for unbalanced panels with time-series dependence. The results from the robust RE estimations are, therefore, reliable even in the presence of these statistical issues and serve as the basis for the interpretation in the subsequent section. The analysis proceeds with Random Effects estimation as the primary modelling strategy, while also presenting Fixed Effects results for robustness and comparison.

Impact of MGNREGA interventions on agricultural outcomes: evidence from panel regression analysis

The panel regression analysis using both FE and RE models revealed differentiated impacts of MGNREGA-related infrastructure and employment variables on agricultural performance across cultivated area, yield, and production in Table 4. Based on the Hausman test, the RE model is preferred, and the following results are discussed primarily in terms of RE estimates, with FE results referenced where relevant.

For cultivated area, land development and drought-proofing showed strong and significant positive associations, indicating that physical asset creation under MGNREGA has contributed to expanded agricultural land use. Employment generation, proxied by person-days of employment, was also positively associated, reinforcing the role of labour provisioning. Notably, micro-irrigation displayed a significant and positive effect only in the RE model, suggesting that irrigation supports yields better outcomes when accounting for state-level time-invariant heterogeneity. However, the effect of total workers was not significant in RE, despite being significant under FE, pointing to localised labour effects rather than general trends.

In terms of agricultural yield, several water-related and infrastructure indicators stood out. Rural drinking water access, micro-irrigation, and rural infrastructure all showed significant positive associations with yield, highlighting the role of water and physical infrastructure in boosting productivity. Conversely, rural sanitation had a consistently negative impact, which may reflect opportunity costs or unintended land-use changes. Land development and water conservation also contributed positively to yield improvements.

For agricultural production, total workers, person employment, and land development were all positively and significantly associated with output in the RE model. Drought-proofing and flood control also had meaningful positive effects, reinforcing the productivity-enhancing potential of climate-resilient assets. However, rural connectivity again showed a negative but significant effect, possibly indicating unintended shifts away from agriculture due to better physical access. Works on individuals and rural sanitation did not exhibit statistically robust effects on production. In summary, the RE model results suggest that MGNREGA's employment and asset-building components, especially those related to land, water, and irrigation infrastructure, have had a significant and positive impact on rural agricultural performance across states.

DISCUSSION

The observed positive associations between variables such as land development, person employment, and micro-irrigation with cultivated area, yield, and production align with the core objectives of MGNREGA–namely, creating durable rural assets while enhancing agricultural productivity and resilience. The consistent and significant impact of land development and person employment across all three agricultural indicators suggests that MGNREGA interventions are not merely income-supporting mechanisms but contribute meaningfully to productive infrastructure. These results support the conclusions of earlier works such as Deininger & Liu

Table 3. Hausman specification test and other diagnostic tests

Test	Area	Yield	Production
Hausman Test (p-value)	0.2855	0.9819	0.2570
Preferred Model	Random Effects	Random Effects	Random Effects
Mean VIF	4.157	4.267	4.012
Breusch–Pagan LM Test (p-value)	0.00307	0.0093	0.0101
Wooldridge Test for Autocorrelation (p-value)	0.0022	0.0000	0.0033
Pesaran CD Test (p-value)	0.0000	0.0041	0.0012
Model Used	RE (1st Diff)	RE (Level)	RE (Level)

Source: Author's calculation

Table 4. RE and FE Regression results for Agricultural outcomes

	Area				Yield				Prodution			
	RE		FE		RE		FE		RE		FE	
	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	P-value	Estimate	Pvalue
Intercept	-0.3502**	0.044			2324.8***	0.000			10.9900*	0.031		
Total.Workers	0.0072	0.223	1.7792***	0.010	1.2988	0.409	2.8634	0.648	0.9422***	0.002	6.7335	0.071
Ruraldrinkingwater	0.0052	0.235	0.0055	0.580	0.0099**	0.011	0.0102**	0.032	0.0006*	0.023	0.0048	0.101
RuralSanit	-0.0010	0.123	0.0023	0.679	-0.0019**	0.031	-0.0021**	0.023	-0.0001**	0.027	-0.0071	0.114
Wage_exp	0.0164**	0.024	-0.0015	0.868	0.0002	0.561	-0.0010	0.609	0.0069	0.606	0.0032**	0.025
Drought_Proof	0.0226*	0.029	0.0584***	0.005	0.0364	0.108	0.0341	0.086	0.0221***	0.001	0.0275**	0.032
Person_employ	0.0198***	0.004	0.0263**	0.030	-0.0123	0.699	-0.0216	0.311	0.0136***	0.003	0.0175*	0.062
LandDeve	0.0173***	0.001	0.0327***	0.006	0.0416	0.234	0.0444	0.234	0.0715	0.004	0.0616**	0.017
MicroIrrig	0.0962***	0.009	-0.0443	0.269	0.0355***	0.002	0.0335**	0.042	0.0192	0.730	0.0343	0.132
FloodControl	0.0214	0.418	0.0172	0.717	-0.0194	0.268	-0.0024	0.267	0.0361*	0.057	0.0306*	0.029
WaterConservation	-0.0592	0.456	-0.0124	0.875	0.0245***	0.000	0.0212**	0.029	-0.0119	0.781	0.0247	0.654
RuralConnect	-0.0346	0.104	0.0102**	0.025	-0.0927**	0.026	-0.0936**	0.030	-0.0449**	0.012	-0.0514*	0.061
Rural_Infra	0.0982	0.414	0.0327	0.706	0.0458***	0.006	0.0455**	0.044	0.0223*	0.046	0.0190*	0.053
Works.on.Individuals	0.0146***	0.001	0.0142	0.421	-0.0529	0.327	-0.0310	0.456	-0.0361	0.205	-0.0430	0.068
R-squared	0.4321		0.3836		0.4635		0.3456		0.5154		0.4123	

Source: Author's calculation; *Note:* *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

(2019), which emphasise that public works programs that combine wage employment with asset creation yield lasting benefits for agricultural livelihoods. Furthermore, the positive impact of micro-irrigation and water conservation measures on yield and production corroborates findings by Shah (2016), who highlights that irrigation-based interventions under MGNREGA lead to more stable and enhanced crop outputs, particularly in semi-arid regions.

The significant contribution of rural drinking water infrastructure to yield points to the broader developmental spill-overs of MGNREGA (Bharne et al., 2025). Improved water access likely facilitates both domestic and farm-related activities, reducing time burdens, especially for women, and allowing more labour allocation toward agricultural tasks (Jatav & Singh, 2023). This observation resonates with studies by Narayanan et al., (2019), which find that the indirect effects of MGNREGA on rural household productivity can be substantial when basic infrastructure is addressed. Conversely, the negative association of rural sanitation infrastructure with both yield and production appears counterintuitive. One plausible explanation is that such investments, although critical for public health, might involve land-use changes or temporary displacement of cultivable land (Jiragal et al., 2025). It also reflects a misalignment between asset type and local agricultural priorities, a concern raised in implementation assessments by Drèze & Khera (2017), who caution that asset utility is often contingent on local relevance and community participation.

Interestingly, rural connectivity, while generally assumed to be beneficial, shows a negative relationship with production in both RE and FE models. This may suggest unintended consequences such as increased labour mobility leading to reduced agricultural labour supply or land-use shifts towards non-agricultural uses. This finding aligns with Yadav & Ghosh (2023), who note that infrastructure development without integrated rural planning can sometimes create sectoral imbalances or labour diversion effects. The study also highlights that not all asset types have uniform effects. For instance, works on individual land does not show statistically significant impacts, which could indicate variability in the scale or sustainability of individual-level assets. These mixed outcomes emphasise the need for rigorous asset planning, ensuring that investments are both need-based and linked to productive outcomes (Nain et al., 2024).

Overall, the trends suggest that when MGNREGA focuses on natural resource management, irrigation, and public employment provisioning, it has tangible positive spill-overs for agriculture. These results support the broader thesis that employment guarantee schemes, when properly implemented, can serve dual goals—short-term income support and long-term rural development. However, the effectiveness is contingent upon the type of asset, regional agroclimatic conditions, and alignment with local needs. Further, while RE models account for time-invariant state-level characteristics and provide a robust analytical framework, localised qualitative assessments remain necessary to fully interpret causality and policy relevance.

CONCLUSION

The study confirms that rural employment schemes play a vital role not only in providing wage employment but also in

improving agricultural outcomes through the creation of productive assets. The results demonstrate that interventions such as land development, drought proofing, water conservation, and localised irrigation positively influence cultivated area, yield, and total agricultural production. Employment creation and community-based infrastructure development emerge as critical enablers of rural agricultural productivity. The evidence suggests that well-targeted rural employment programs can deliver lasting benefits to the agricultural sector, particularly when infrastructure is tailored to local agroecological needs. These findings validate the hypothesis that asset-building under such schemes contributes meaningfully to agricultural performance. It should now be recognised that the integration of rural employment programs with agricultural planning is essential for achieving sustainable rural development. The research implies that policy design must continue to emphasise asset quality, regional targeting, and long-term agricultural relevance.

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Research Article

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Effect of Joint Liability Groups on the Improvement of Paddy Farming in Thrissur District, Kerala

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HIGHLIGHTS

- Optimum production of paddy is vital for food security, while its area of cultivation has been declining in Kerala.
- Sub-optimum size of land holding is one of the major constraints in the ever-rising cost of paddy cultivation in Kerala.
- Joint liability groups have improved paddy farming in Thrissur district.

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Keywords: Agriculture, Paddy farming, Collective farming, Joint liability groups.

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ABSTRACT

To overcome the obstacles such as small landholdings, high cost of labour, shortage of credit, and modest mechanisation, collective farming initiatives like joint liability groups were launched in Kerala. Earlier research on joint liability groups in the agricultural arena of Kerala has rarely examined the effects of joint liability groups (JLGs) on the improvement of paddy cultivation. To find out the effect of JLGs, the present study has collected primary data from the Thrissur district of Kerala. The primary survey was conducted from January 2025 to April 2025. Statistical tools such as analysis of variance (ANOVA) and post-hoc tests were used to analyse the data. The findings indicated that operations of joint liability groups are effective in improving the production of paddy, reducing labour cost, and improving the marketing facilities of paddy cultivation in Thrissur district. The study recommends that the state government should support the joint liability groups to endure and triumph in paddy cultivation.

INTRODUCTION

The productivity of paddy has been declining for the last three decades in Kerala. For instance, in 2023-24, the area under paddy cultivation was 1.8 lakh hectares, showing a decrease of 5.9 per cent as compared to 2022-23. There are various causes that hinder the growth of paddy production in Kerala. Considering various problems in paddy cultivation, the Government of Kerala (GoK) has implemented specific schemes to improve the production of paddy. Most of these initiatives work as part of the state planning process and annual budgets (Sajesh, 2013; Titus, 2020; Vijayan, 2022; Kerala Economic Review, 2024).

Apart from the implementation of various initiatives of Government of Kerala, Kerala had marginal improvement in the production of paddy. The major obstacles of paddy farmers are small and fragmented holdings, poor access to credit, high cost of labour, inadequate marketing facilities, and shortage of labour. Group farming will be beneficial to access the benefits of 'economies of scale' and 'accessibility credit' (Goulet, 2013; Rejula et al., 2017; Bharath et al., 2024). Based on the benefits of collective farming, an initiative has been started in Kerala. i.e. joint liability groups. A 'JLG' is an informal association consisting of farmers who unite to secure a bank loan and operate joint farms collectively as a group. Members of JLGs collectively provide a joint commitment to the bank and facilitate their access to loans. JLGs liability groups have an active involvement in a wide range of activities in agriculture, thereby fostering economic growth and food security. Joint liability groups continued collective farming by organising farmers to take

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up lease land farming to empower farmers economically and help Local Self Governments (LSGs) to achieve food security. In Kerala, the total landholding under joint liability groups is 4459.15 hectares during the period 2023-24. Among the total land area of joint liability groups in Kerala, Thrissur district has the highest area of land holdings. More specifically, around quarter of the landholdings under joint liability groups were operated in Thrissur district (Thomas, 2004; Srinivasan, 2012; Ravikumar & Sudheesh, 2013; Sajesh, 2013; Pammi & Malamasuri, 2014; Titus, 2020; Krishnankutty et al., 2021; Kerala Economic Review, 2024; Rajkumar, 2024).

The data indicates that there is a growing importance on JLGs in paddy farming of Kerala. However, previous research has rarely examined the effect of joint liability groups on the progress of paddy farming. Although joint liability groups in paddy farming have gained momentum in Kerala, their progress has to be scientifically analysed. In this context, the major objective of the present study was to analyse the effect of joint liability groups on the improvement of paddy farming in Thrissur district. In addition, differences in the effect of joint liability groups on paddy farming concerning selected variables were also a major area of concern. This novel approach and findings from the present study will fill the existing research gap. Furthermore, it will contribute to the existing literature by suggesting measures to improve the impact of paddy farming in Kerala.

METHODOLOGY

The purpose of the present study was to analyse the effect of joint liability groups in the improvement of paddy cultivation in Kerala. The present study was conducted in Thrissur district of Kerala. The number of 'joint liability groups' and the 'area under paddy cultivation' are the highest in Thrissur district (Kerala Economic Review, 2024). Therefore, Thrissur district has been selected for an in-depth investigation. The sampling framework to collect the primary data is as follows. Firstly, the district was classified into block panchayaths. From each block panchayath, total joint liability groups in paddy farming were identified. It was collected from the data of Krishi Bhavans, village offices and block panchayath offices in Thrissur district. There are 16 block panchayaths in Thrissur district. Eight groups were selected from each block panchayath. The sample size was determined through the following process. There are four types of groups with respect to the number of farmers in each group. Therefore, four groups were selected from each block and it accounts 84 groups. From each group, 4 types of sample farmers were required. Sample size constituted 336 paddy farmers. Subsequently, joint liability groups were classified into four sub-groups. They are: (i) group of upto 8 paddy farmers; (ii) 9-12 paddy framers; (iii) 13-18 paddy farmers and (iv) 19 and above paddy farmers. From each group, farmers were stratified with respect to their socio-economic and agricultural characteristics. These characteristics are educational level of farmers, experience of farmers in farming, land area under cultivation and age of farmers. Subsequently, the farmers were selected randomly from each stratum. The present study followed 'proportionate sample size technique' through 'Lahiri method' to identify the sample farmers from each stratum (Hounyo & Lahiri, 2023). Subsequently, a 'semi-structured questionnaire' has been prepared. The semi-structured questionnaire contains six sections and sub-sections. The sections consist of socio-economic characteristics of farmers in liability groups, demographic features, structure of groups, improvement in paddy production, cost of labour, marketing facilities, experience of farmers, land area of groups and satisfaction of farmers.

A pilot study was conducted among joint liability groups in Thrissur district. The interactions were fixed after seeking the convenience and availability of respondents. Data collected through pilot survey was tested for consistency and validity using Cronbach's Alpha (Kennedy, 2022). Based on the insights from pilot study, final primary survey has been fixed. As per the convenience of the sample farmers from respective groups, face-to-face interviews were conducted. Finally, the present study has collected the information from 336 paddy farmers who participated in joint liability groups. In addition, the information has been collected from selected office bearers of sample joint liability groups. The final primary survey was conducted through face-to-face mode between January 2025 and April 2025. Each interview with respondents took almost 40 to 45 minutes. Responses of the sample farmers were collected in a 5-point Likert scale. Subsequently, the present research considered the factors such as nature of the data, objectives and previous literature to choose the tools of statistical analysis. Based on the insights from methodological review and sample survey, the present study selected statistical tools such as Mean, ANOVA test and post-hoc test to analyse the data. To apply these tests, the assumptions such as normality, homogeneity of variance and independence of observations were used (Kozak & Piepho, 2018).

RESULTS

The basic profile of the primary data collected from the sample district is exhibited in Table 1. Column 1 contains socio-economic, demographic and agricultural variables such as number of farmers in each group, average holding of each group (in hectares), average experience of farmers in farming (years), average age of farmers and average educational qualification of farmers. The framework to classify and present the primary data was adapted from various sources. They are: (i) discussion with Krishi Bhavan officers; (ii) discussion with village officers; (iii) insights from Kerala Economic Review; (iv) pilot survey and (v) publication of government of Kerala such as compendium of Agricultural Statistics. Based on these sources, the data is classified as follows (A Compendium of Agricultural Statistics: Kerala 2023; Kerala Economic Review, 2024). Based on the insights from these factors, a row-wise classification is presented in column 2 of Table 1. Firstly, the number of paddy farmers in joint liability groups were categorised with respect to the number of paddy farmers in each liability group.

The characteristics of the primary data is as follows. Firstly, the classification of number of farmers in each group is presented. There are 28 farmers from group 1 (upto 8 farmers group) followed by 24 farmers from group 2 (9-12 farmers), 21 farmers from group 3 (13-18 farmers) and 11 farmers from group 4 (19 and above). The first group (28 farmers) has the highest number of paddy farmers in Thrissur district. Secondly, the classification of 'average

Table 1. Basic Profile of the Sample Groups in Kerala

Variables	Categories	Frequency/percentage
Sample Joint Liability Groups (Number)	Up to 8	28 (33)
	9-12	24 (29)
	13-18	21 (25)
	19 and above	11(13)
	Total	84 (100)
Average Holdings (in hectares) of JLGs	Up to 10	16 (19)
	11-15	31 (37)
	16-20	25 (30)
	21 and above	12 (14)
	Total	84 (100)
Average Experience of Paddy Farmers (Years) in JLGs	Up to 15	74 (22)
	16-20	101 (30)
	21-25	105 (31)
	26 years and above	56 (17)
	Total	336 (100)
Age of Farmers (Years) in JLGs	Up to 45	39 (12)
	46-50	107 (32)
	51-55	132 (39)
	56 and above	58 (17)
	Total	336 (100)
Educational Qualification of Paddy Farmers in JLGs	Up to 7th standard/Primary Education	43 (13)
	8th standard to 10th standard	174 (52)
	Higher Secondary/Plus two	105 (31)
	Graduation and above	14 (4)
	Total	336 (100)

Notes: (1) Classifications adapted from Kerala Economic Reviews and discussions with Krishi Bhanvan officers; (2) Figures in Parentheses indicate percentage to sub-total; *Source:* Authors computed from primary data

holding of land among joint liability groups' is as follows. They are: (i) upto 10 hectares; (ii) 11-15 hectares; (iii) 16-20 hectares and (iv) 21 and above hectares. Joint liability groups who have 11-15 hectares of land are the highest (37.0 per cent) as compared to other sample groups of Thrissur district in Kerala.

The third characteristic of the joint liability groups is the 'experience of paddy farmers', which is exhibited and classified as follows. They are: (i) Upto 15 years (ii) 16 to 20 years; (iii) 21 to 25 years; (iv) 26 years and above. Data indicates that average experience of farmers is the highest to the third group (31.0%). It seems that farmers in joint liability groups have adequate experience in farming. It may be argued that there would be a positive relationship between agricultural experience of farmers in groups and production of agricultural output (Goodwin et al., 2002; Panneerselvam et al., 2012; Goulet, 2013).

Fourthly, the average age of farmers in joint liability groups is presented. It was found that the majority of the farmers in the joint liability groups are in an age group of 51-55 years. Fifthly, the educational qualification of paddy farmers is examined. It is found that average educational qualification of farmers in joint liability groups is 8-10 standard (52%). It indicates that they require expert support to improve their awareness in scientific paddy farming practices.

After the classification of characteristics of respondents, the present study analysed the effect of joint liability groups on the progress of paddy farming in Thrissur district. The perceptions of farmers in joint liability groups were coded, categorised and applied with statistical tools. The results of the analysis were presented in Table 2, Table 3, Table 4 and Table 5. Data on Table 2 indicates that Mean and Standard Deviation (SD) on perceptions of farmers on the improvement of paddy farming is normally distributed.

The Cronbach Alpha and ANOVA-test results are exhibited in Table 3. The score of Cronbach Apha is 0.90 and it was satisfied with the standard benchmark. It indicates that the scale used in the present research is reliable and satisfactory (Kennedy, 2022). The p-value and F-values are also found to be significant. The p-value calculated for the 'average land holding of joint liability group' is 0.000 which is very low as compared to the standard benchmark (0.05% significance level).

The p-value calculated for the 'average experience of paddy farmers in joint liability group' is 0.003 which is very low and it is

Table 2. Farmers' Perception on the Effect of Joint Liability Groups in Paddy Farming

Items	Mean	SD
The quantity of Paddy production improved	5.47	1.253
Satisfaction increased in collective farming	5.26	1.297
The approach of financial institutions was improved	5.18	1.723
Credit Facilities improved	5.39	1.117
Cost of labour reduced	5.48	1.465
Marketing facilities improved	5.62	1.386

Source: Authors computed from primary data

Table 3. Cronbach Alpha Score and ANOVA Results

Cronbach Alpha Score					
Variable		Questions asked	Score	Test result	
Improvement in Paddy farming		6	0.90	satisfied	
ANOVA Results (Average Land Holding)					
Disparity	Sum of squares	Degree of Freedom	Mean square	F-Value	Significance
Between Groups	10516.244	3	2629.061	7.056	0.000
Within Groups	40357.300	333	188.586		
Total		336			
ANOVA Results (Average Experience of Paddy Farmers)					
Disparity	Sum of squares	Degree of Freedom	Mean Square	F-Value	Significance
Between Groups	3170.0333	3	1056.678	4.762	0.003
Within Groups	47703.511	333	221.877		
Total	50873.544	336			

Source: Authors computed from primary data

significant. It is evident from the data presented in Table 3 that 'average land holdings' and 'average experience of farmers' has shown a positive effect of the joint liability groups in the improvement of paddy farming.

Based on the significant results of ANOVA test, post-hoc test is applied. Post-hoc test was applied to test the difference of significance between perceptions towards effect of joint liability groups in paddy farming. The post-hoc test results are presented in Table 4 and Table 5. Post-hoc test was applied to test the difference between perceptions towards the effect of joint liability groups in the improvement of paddy farming in every group with respect to selected variables. The post-hoc test was conducted in selected groups such as 'average land holdings of paddy farmers in joint liability groups' and 'average experience of paddy farmers in joint liability groups. Results of the post-hoc test with respect to these variables are presented in Table 4 and Table 5 respectively. Results in Table 4 indicates that in the 'higher land holdings' under joint liability groups would have significant positive effect in the paddy farming of Thrissur district. Results indicate that on the basis of 'different level of land holdings' of paddy farmers, most of the farmers have positive perceptions towards improvement of paddy cultivation in group farming.

Results in Table 5 indicates that the 'experience of paddy farmers in joint liability groups' are positively related to the paddy farming in Thrissur district. It may be inferred that different levels of 'agricultural experience' and 'average land holdings' are positively related to improvement of paddy farming in joint liability groups of Thrissur district.

In a nutshell, the results of the analysis argue that larger number of paddy farmers have positive perceptions regarding the effect of farmer groups on the factors such as quantity of paddy production, financial support to paddy farming, marketing facilities of farmers and reduction in cost of labour.

DISCUSSION

The present study analysed on the effect of joint liability groups in paddy farming in Thrissur district of Kerala. Findings indicated that joint liability groups have made a positive effect in the production of paddy in Thrissur district. Therefore, it may be inferred that promotion of joint liability groups would improve the production of paddy in Thrissur district. This finding seems to be indirectly supported by the earlier literature on joint liability groups in agriculture and microfinance. Some previous findings have shown a similar finding on paddy farming while others have exhibited a

Table 4. Post-Hoc test (Multiple comparisons) on Size of the Holdings

Land Holdings	Land Holdings	Mean	Std.Error	significance	95% Confidence Interval	
(In hectares) (I)	(In hectares) (J)	Difference			Lower bound	Upper Bound
UP to 10	Nov-15	-0.900376	2.4984434	0.523	-6.3810243	4.411053
	16-20	17.0025514*	5.214861	0.043	6.3404566	27.247028
	21 and above	-2.1241185*	3.3462052	0.021	-8.2202661	3.9672716
Nov-15	UP to 10	0.900376	2.4984434	0.523	-4.411053	6.3810243
	16-20	17.8211295*	4.9267687	0.013	8.1887493	27.601927
	21 and above	-1.0832736*	2.4874571	0.01	-6.1587773	3.7422905
16-20	UP to 10	-17.0025514*	5.214861	0.043	-27.247028	-6.3404566
	Nov-15	-17.8211295*	4.9267687	0.013	-27.601927	-8.1887493
	21 and above	-18.8572455*	5.2670547	0.004	-29.151524	-8.6767703
21 and above	UP to 10	2.1241185*	3.3462052	0.021	-3.9672716	8.2202661
	Nov-15	1.0832736*	2.4874571	0.01	-3.7422905	6.1587773
	16-20	18.8572455*	5.2670547	0.004	8.6767703	29.151524

Source: Authors computed from primary data

Table 5. Post-Hoc test (Multiple comparisons) on experience of farmers

Experience of Paddy Farmers (Years) in JLGs	Experience of Paddy Farmers (Years) in JLGs	Mean Difference (I-J)	Std.Error	significance	95% confidence interval	
					Lower bound	Upper Bound
UP to 15	16-20	5.3878435	2.3690757	.061	0.2282733	10.3033308
	21-25	20.9776004*	4.7894528	.020	11.2422785	30.5976896
	26 and above	8.6289034*	3.0868245	.009	2.9176033	14.2419373
16-20	UP to 15	-5.3878435	2.3690757	.061	-10.3033308	-0.2282733
	21-25	15.5971010*	4.6633154	.012	6.3940826	24.6971258
	26 and above	3.4229543*	2.5448902	.005	-1.5283844	7.7340121
21-25	UP to 15	-20.9776004*	4.7894528	.020	-30.5976896	-11.2422785
	16-20	-15.5971010*	4.6633154	.012	-24.6971258	-6.3940826
	26 and above	-12.4157346*	4.7793007	.003	-21.7330392	-2.8709741
26 and above	UP to 15	-8.6289034*	3.0868245	.009	-14.2419373	-2.9176033
	16-20	-3.4229543	2.5448902	.005	-7.7340121	1.5283844
	21-25	12.4157346*	4.7793007	.003	-21.7330392	-2.8709741

Source: Authors computed from primary data

mixed result (Sajesh, 2013; Madhuri & Gupta, 2014; Titus, 2020; Sreejith, 2023; Sabu & Roy, 2024).

Secondly, the present study has identified that there are some variables which could affect the performance of joint liability groups in Thrissur district. For instance, the average size of the holdings of farmers in joint liability groups had a positive impact on paddy farming. These findings are seemingly similar in some of the earlier findings on joint liability groups in agriculture and related sectors. For instance, previous research argue that collective farming has a crucial role in determining the size of the land holding and accessibility of credit (Sajesh, 2013; Pammi & Malamasuri, 2014; Sreejith, 2023; Patil & Mehta, 2024).

Thirdly, the present study inferred that the agricultural experience of farmers in joint liability groups has a significant impact on the improvement of paddy cultivation. It might have indirectly promoted the rural paddy-entrepreneurship and micro-finance among paddy farmers. In other words, there would be a positive correlation between the experience of paddy farmers and performance of joint liability groups. These findings seem to be implicitly comparable to some of the previous findings on group farming in agriculture in general and paddy cultivation in particular. More specifically, previous research argued that experience of farmers has a crucial role in determining the agricultural output (Cherian & Ramchandran, 2012; Titus, 2020; Sreejith, 2023; Chundru et al., 2024).

CONCLUSION

Variables such as the agricultural experience of farmers and the size of the landholdings of joint liability groups have had a positive effect on the paddy farming of Thrissur district. Local Self-Governments (LSGs) and paddy farmers have crucial roles to play to improve paddy production. Local Self-Governments can take initiatives and thereby optimize the average land holdings in joint liability groups. Awareness programmes in collective paddy farming will be beneficial to improve the knowledge base of paddy farmers. It can supplement the experience and educational level of paddy farmers. Monetary and non-monetary incentive mechanisms to join collective farming will also be fruitful. Government of Kerala (GoK) should allocate enough resources in the annual budgets of the state to support joint liability groups.

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Research Article

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Fading Echoes of Tradition: The Transformation of Intergenerational Farming Knowledge in Toto Tribal Communities

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HIGHLIGHTS

- Toto tribal community in West Bengal witnessed a gradual shift from traditional knowledge systems to modern techniques, particularly among younger generations.
- Knowledge erosion is attributed to reduced social participation and changing family aspirations.
- Among tribal communities promoting elder-youth knowledge exchange is crucial for preserving traditional knowledge and enhancing climate resilience.
- Socio-economic factors like family educational status and material possessions positively influenced agricultural livelihood.

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ABSTRACT

Indigenous knowledge systems have traditionally played an important role in supporting agricultural livelihoods, particularly in tribal populations. The Toto tribe, an endangered indigenous population in West Bengal, India, has relied on intergenerational knowledge transmission to ensure sustainable farming practices but their traditional wisdom is at risk due to socio-economic changes and modernization. The study examines the various socio-economic factors influencing the transmission of agricultural knowledge within Toto family farms, analyzing the impact of intergenerational exchange on agricultural sustainability. A mixed-methods approach was employed, integrating qualitative participatory research with quantitative data analysis. Data were collected through Focus Group Discussions, personal interviews, participant observation and structured household surveys among 120 Toto family farms in Totopara village. Pearson's Correlation Analysis assessed socio-economic factors influencing livelihood choices, while thematic coding in ATLAS.ti identified patterns of knowledge retention and transformation. The study reveals a generational gap in farming knowledge due to shifts in aspirations, formal education, and reduced reliance on traditional farming techniques. Modernization has improved efficiency but displaced indigenous methods like seed preservation and water conservation. Integrating traditional knowledge with modern advancements is crucial for climate-resilient and sustainable farming. Policy interventions, community-led conservation efforts and indigenous education programs are critical for preserving agricultural heritage.

INTRODUCTION

Indigenous communities worldwide have long depended on intergenerational knowledge systems to sustain their livelihoods, particularly in agriculture (Singh et al., 2022). These knowledge systems, deeply embedded in cultural traditions, play a crucial role in shaping farming practices, resource management, and resilience to environmental changes (Jakes, 2024; Talwar & Singh, 2024).

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Among such communities, the Toto an aboriginal Indo-Bhutanese tribe of West Bengal, India, represents a small and endangered indigenous group whose agricultural practices have been guided by traditional wisdom for generations (Hossain, 2022). Intergenerational knowledge transmission in agriculture involves the passing down of farming skills, ecological understandings, and resource management techniques from elders to younger generations (Wójcik et al., 2019; Akhmar et al., 2023). Within the Toto community, this exchange of wisdom is not a simple transfer of information but a dynamic and adaptive process shaped by changing climatic conditions, market integration, and socio-political shifts (Priyadarshini et al., 2020). Traditionally, knowledge transmission occurred through oral traditions, hands-on demonstrations, and ritualistic practices, ensuring that younger generations acquired practical farming skills and a deep ecological understanding of their environment (Rayis et al., 2023). This indigenous farming knowledge, accumulated over centuries, enabled the Toto people to maintain sustainable agricultural practices through diverse cropping patterns, soil conservation techniques, and locally adapted water management systems (Priyadarshini & Abhilash, 2019). Shifts in aspirations, urban migration and formal education systems that do not integrate indigenous knowledge have led to the gradual erosion of these traditional learning pathways.

Studies have indicated that indigenous knowledge systems are increasingly vulnerable to rapid socio-economic changes, technological advancements, and declining youth participation in traditional livelihoods (Kom et al., 2024; Macusi et al., 2023). While modern agricultural interventions have introduced efficiency and higher yields, they have also contributed to the displacement of time-tested indigenous farming techniques, including traditional seed preservation, organic pest management, and community-based water conservation practices (Sharma et al., 2020). The diminishing role of elders in guiding agricultural decisions further exacerbates this knowledge loss, creating a generational disconnect in farming wisdom (Aswani et al., 2018). Despite these challenges, traditional farming knowledge preservation is crucial for agricultural sustainability and climate resilience, as it has historically enabled tribal communities to adapt to environmental changes through climate-responsive farming strategies (Kumar, 2015). Therefore, striking a balance between preserving traditional farming practices and integrating contemporary innovations is essential for sustaining Toto tribal agriculture in the face of modernization.

This study aims to examine the transmission of traditional agricultural knowledge within Toto family farms, assess the roles of elders and youth in preserving and adapting indigenous farming techniques, and analyse the impact of intergenerational knowledge exchange on the sustainability and resilience of the Toto tribal farming system. By focusing on these aspects, the research contributes to the broader discourse on indigenous knowledge retention, agricultural adaptation and climate resilience in tribal communities.

METHODOLOGY

This study adopted a mixed-methods approach, integrating qualitative participatory research techniques with quantitative data analysis to examine the decline of traditional farming knowledge among the Toto tribe. The study was conducted in Totopara Village, Madarihat Block, Alipurduar District, West Bengal, in the year 2024-2025, where the Toto community primarily resides. A purposive sampling technique was employed to select 120 family farms, ensuring representation across different age groups (elders, middle-aged farmers, and youth) to capture generational differences in knowledge retention and transmission. A combination of qualitative and quantitative data collection methods was employed to ensure triangulation and reliability. Focus Group Discussions (FGDs) were conducted separately with elders, youth, and women to understand patterns of knowledge transfer, perceptions of modernization, and emerging challenges. Oral history interviews were used to document traditional farming practices and their transformation over time. Participant observation was undertaken to directly examine farming activities and validate the insights obtained from interviews and FGDs. Additionally, structured household surveys were administered to gather demographic data, farming practices, and the extent of knowledge transmission within families. For quantitative analysis, descriptive statistics (mean, standard deviation, and coefficient of variation) were used to summarize the data, while Pearson's Correlation Analysis examined relationships between socio-economic variables with agricultural and non-agricultural livelihoods. SPSS is used for quantitative data analysis. Qualitative data were analyzed using thematic coding in ATLAS.ti. Transcribed FGDs, oral histories, and observational notes were systematically coded to identify key themes. An open coding process was used to develop initial codes, followed by categorization to group related concepts. The final themes were refined through code co-occurrence analysis, which helped establish connections between factors influencing knowledge loss. Network visualization in ATLAS.ti provided insights into how socio-economic changes and modernization contributed to shifts in indigenous agricultural practices.

RESULTS

Correlation analysis

The correlation table provides insight into the relationship between independent and dependent variables (Y_1: Livelihood in Agriculture and Allied Sectors, Y_2: Livelihood Activities Other than Agriculture and Allied Sectors). Data from Table 1 shows that family education status (r = 0.282) is positively significant with Y_1 at 5% level of significance (p = < 0.05) whereas, primary occupation (r = 0.454), land holding (r = 0.649), material possession (r = 0.529) and attitude towards adoption of innovation (0.479) were positively significant with dependent variable Y_1 at 1 % level of significance (p = < 0.01). Mass media exposure (r = -0.200) was negatively significant at 5% level of significance (p< 0.05) and innovativeness (r = -0.417) was negatively significant with Y_1 at 1% level of significance (p < 0.01). Other independent variables such as age, education, family size, house type, social participation and cosmopoliteness were non-significant with Y_1.

Accordingly, education (r = 0.287) and family education status (r = 0.289) were positively significant with Y_2 at 5% level of significance (p< 0.05) while family size (r = 0.367) was positively correlated with Y_2 at1 % level of significance (p = < 0.01).

Table 1. Correlation analysis of selected independent variables with dependent variables (n=120)

Variable	r (Y_1)	"p" value	r (Y_2)	"p" value
Age	-0.155	0.091	-0.124	0.177
Education	0.139	0.130	0.287*	< 0.05
Family Size	0.013	0.888	0.367**	< 0.01
Family Education Status	0.282*	< 0.05	0.289*	< 0.05
Primary Occupation	0.454**	< 0.01	0.036	0.696
Land Holding	0.649**	< 0.01	0.067	0.480
Material Possession	0.529**	< 0.01	0.044	0.631
House Type	-0.010	0.910	-0.129	0.161
Social Participation	-0.079	0.395	-0.181	0.050
Cosmopoliteness	0.164	0.070	0.032	0.730
Mass Media Exposure	-0.200*	< 0.05	-0.031	0.737
Innovativeness	-0.417**	< 0.01	-0.327*	< 0.05
Attitude Towards Adoption of Innovation	0.479**	< 0.01	-0.010	0.910

Significance: *p < 0.05, **p < 0.01

Y_1: Livelihood in Agriculture and Allied Sectors; Y_2: Livelihood Activities Other than Agriculture and Allied Sectors

Innovativeness (r = -0.327) was negatively significant with Y_2 at 1% level of significance (p = < 0.01). Other variables such as age, occupation, land holding, material possession, house type, social participation, cosmopoliteness, mass media exposure and attitude towards adoption of innovation were non-significant with Y_2.

Thematic analysis

A graphical representation of thematic analysis is shown in Figure 1 through a network diagram.In the diagram, different categories of themes were denoted by different colours: Light Blue No des: Main Themes (Knowledge Erosion, Adaptation to Modern Techniques, Youth Perspectives on Traditional Farming), Light Green Nodes: Sub-categories (Factors influencing each theme), Light Coral Nodes: Key Variables with Correlation Values.

Theme 1: Knowledge Erosion

Knowledge erosion was the main theme, analysed by the thematic analysis of FGDs that was recorded at the time of data collection. Knowledge erosion was connected with three green nodes i.e. education and knowledge loss, material possession impact and social participation decline. These green nodes were further connected by independent variables (red node) such as education, material possession and social participation.

The analysis identified education as a key factor influencing knowledge retention, with a moderate positive correlation between education and agricultural livelihood (r = 0.139) and non-agricultural livelihood (r = 0.287). Material possession and economic stability were significantly associated with traditional agricultural practices. Material possession showed a strong correlation with agricultural livelihood (r = 0.529) and a weaker correlation with non-agricultural livelihood (r = 0.044). Social participation and oral knowledge transfer were linked to community interaction. Social participation exhibited a weak negative correlation with agricultural livelihood (r = -0.079) and non-agricultural livelihood (r = -0.181).

Theme 2: Adaptation to Modern Techniques

Adaptation to modern techniques emerged as a key theme, represented by the light blue node in the network diagram. This theme was linked to three sub-themes: landholding and occupational shifts, attitude towards innovation, and innovativeness and traditional practices, denoted by green nodes. These sub-themes were further associated with independent variables, represented by red nodes, including landholding, attitude towards innovation, and innovativeness.

Landholding showed a highly significant correlation with agricultural livelihood (r = 0.649) and a less significant correlation with non-agricultural livelihood (r = 0.067), indicating its influence on the adoption of modern techniques. Attitude towards innovation had a positive correlation with agricultural livelihood (r = 0.479) and a slightly negative correlation with non-agricultural livelihood (r = -0.010), reflecting generational differences in the perception of innovation. Innovativeness was identified as a divisive factor, with a negative correlation with agricultural livelihood (r = -0.417) and non-agricultural livelihood (r = -0.327), suggesting that higher innovativeness was associated with a shift away from traditional farming practices.

Theme 3: Youth Perspectives on Traditional Farming

Youth's perspective on traditional farming emerged as a central theme, influenced by cosmopoliteness & urban influence, mass media & changing aspirations, and family size & generational trends, represented by green nodes in the network diagram. These factors were connected to independent variables such as cosmopoliteness, mass media exposure, and family size, denoted by red nodes.

Cosmopoliteness and exposure to urban influences play a crucial role in shaping livelihood choices. Cosmopoliteness demonstrated a positive correlation with both agricultural livelihood (r = 0.164) and non-agricultural livelihood (r = 0.032). Similarly, mass media exposure and evolving aspirations are key factors influenced by the level of media engagement. Mass media exposure showed a negative correlation with agricultural livelihood (r = -0.200) and non-agricultural livelihood (r = -0.031). Family size and generational farming trends significantly impact livelihood patterns. Family size exhibited a weak correlation with agricultural livelihood (r = 0.013) but showed a moderate correlation with non-agricultural livelihood (r = 0.367).

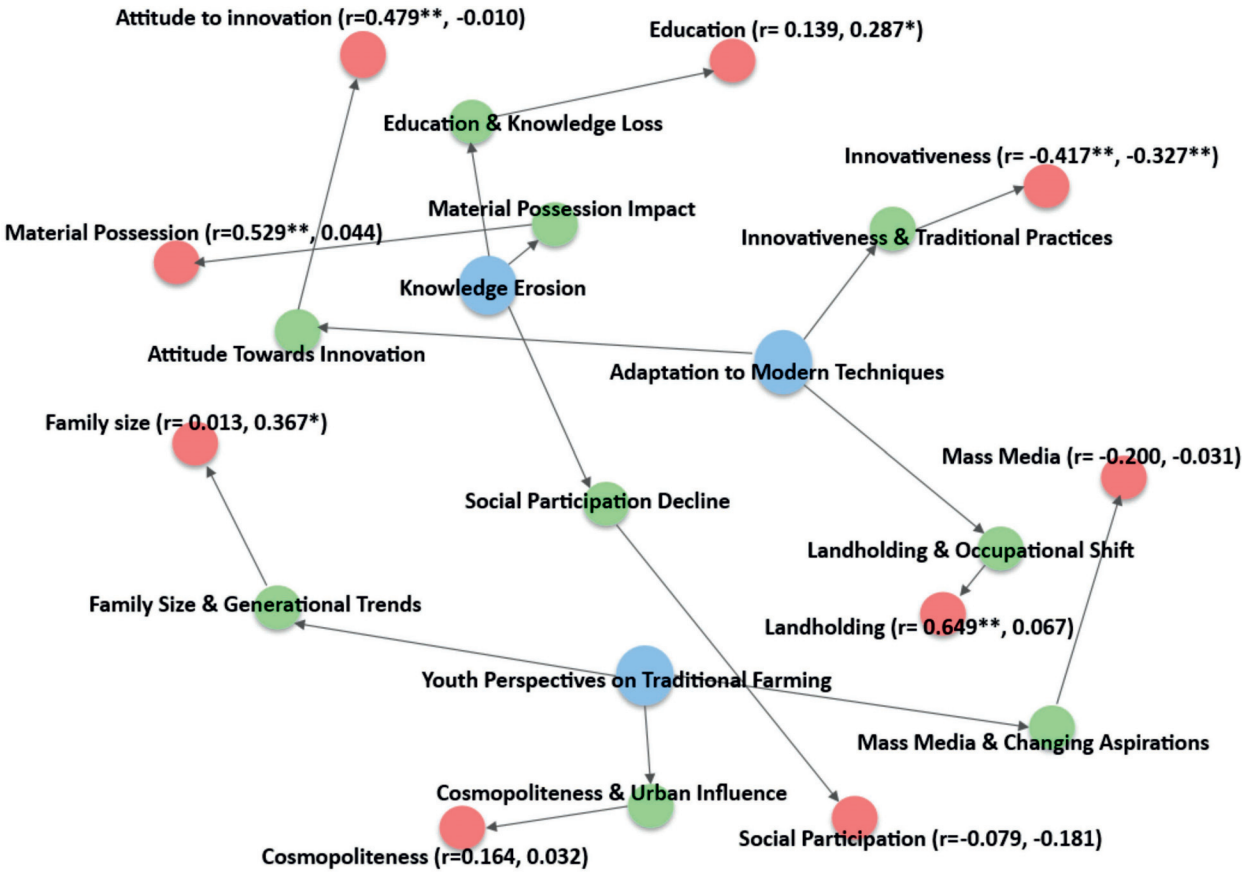

Figure 1. Graphical representation of thematic analysis using a hierarchical network diagram

DISCUSSION

The correlation analysis provides valuable insights into the factors influencing livelihood choices in both agricultural and non-agricultural sectors. The findings highlight the significance of various socio-economic attributes in determining an individual's inclination toward these livelihood options.

Education was significantly correlated with non-agricultural livelihood, while family education status showed a significant positive correlation with both agricultural and non-agricultural sectors. indicating that households with higher educational attainment tend to pursue diversified livelihoods. This suggests that education enhances decision-making and adaptability, enabling households to simultaneously engage in agriculture using improved practices and explore non-farm employment opportunities, supporting the findings of Gautam & Andersen (2016), who found that education strengthens livelihood diversification in rural settings. Family size showed a non-significant relationship with agricultural livelihood and a positive significant relationship with non-agricultural livelihood, which indicates that a larger family size might necessitate diversification of income sources, thereby pushing individuals toward non-agricultural ventures. Similarly, primary occupation was significantly associated with agricultural livelihood, suggesting that individuals whose main occupation is agriculture are more likely to continue their livelihoods in the sector, a finding consistent with Pal et al., (2017) & Pradhan et al., (2021), who observed occupational commitment as a key factor in agricultural engagement. Landholding and material possession had a strong and highly significant association with agricultural livelihood due to which landholding emerged as a critical determinant of agricultural livelihood, as access to larger land enables greater productivity and income stability. Material possession also played a supportive role, emphasizing that asset-rich households are better equipped to sustain agriculture. Whereas, mass media exposure showed a negative and significant correlation with agricultural-based livelihood, indicating that higher media access may encourage livelihood diversification away from agriculture. Similar findings were reported by Baird & Hartter (2017) & Ghosh et al., (2017), who observed that increased exposure to television, internet, and mobile platforms led rural youth to explore non-farm employment opportunities, reducing reliance on traditional farming. Attitude towards adoption of innovation was positively correlated with agricultural livelihood, implying that receptiveness to new technologies enhances agricultural participation. Conversely, innovativeness showed a negative and significant correlation with both agricultural and non-agricultural sectors. This suggests that individuals with higher tendency to innovate may prefer to disengage from both traditional farming and conventional non-agricultural livelihoods, possibly opting for novel or entrepreneurial pathways. A similar pattern was observed by Sekhar et al., (2024), who noted that rising innovativeness among rural youth coincided with a decline in traditional engagement in both farming and wage-based work. Other

independent variables, such as age, education, family size, house type, social participation and cosmopoliteness, were found to be non-significant with respect to agricultural livelihood, suggesting their limited direct influence on agricultural engagement. The results are similar with the findings of Pradhan et al., (2021) who reported that socio-demographic factors alone are insufficient to determine agricultural participation in rural settings. Similarly, variables such as age, occupation, landholding, material possession, house type, social participation, cosmopoliteness, mass media exposure, and attitude towards adoption of innovation, were found to be non-significant with non-agricultural livelihood, indicating that these factors do not strongly determine engagement in non-agricultural activities. The findings of the study are in line with the work of Munawar et al., (2022) who highlighted that non-agricultural livelihood choices are often influenced more by external factors like infrastructure access, skill availability, and market connectivity than by household socio-economic characteristics.

The thematic analysis using a hierarchical network diagram reveals the complex interplay of socio-economic, cultural, and technological factors in shaping indigenous agricultural knowledge transformation. The first major theme, knowledge erosion, highlights the role of formal education, economic stability, and social participation in diminishing traditional farming knowledge. Education exhibits a weak correlation with agricultural livelihood (r = 0.139) but a stronger positive correlation with non-agriculture livelihood (r = 0.287), reflecting a shift away from farming among the educated youth. Economic stability, marked by material possession (r = 0.529), increases reliance on modern tools, further eroding indigenous techniques. The declining role of social participation (r = -0.079 with agriculture livelihood and r = -0.181 with non-agriculture livelihood) weakens oral knowledge transfer and collective farming traditions. A similar conclusion was also drawn by Rao (2024) in his work related to the erosion of indigenous knowledge. The second theme, adaptation to modern techniques, underscores how landholding patterns, attitudes toward modernization, and innovation adoption influence traditional farming. Larger landowners, highly correlated with agriculture livelihood (r = 0.649), integrate hybrid farming, while smallholders, constrained by resources, retain traditional methods. A significant generational divide is evident in the attitude toward innovation (r = 0.479 with agriculture livelihood), where youth embrace modern techniques while elders resist, leading to a shift from organic to chemical-based inputs. Innovativeness, negatively correlated with agriculture livelihood (r = -0.417) and non-agriculture livelihood (r = -0.327), further widens the rift as modern experimentation discourages traditional practices. A similar finding was also given by Sekhar et al., (2024). The third theme, youth perspectives on traditional farming, is shaped by urban exposure, mass media influence, and family structures. Higher cosmopoliteness correlates with agriculture livelihood (r = 0.164), indicating migration-induced detachment from farming, while mass media exposure negatively correlates with agriculture livelihood (r = -0.200), showcasing its role in diverting youth aspirations toward non-agricultural careers. Family size (r = 0.367 with non-agriculture livelihood) plays a critical role, where larger families retain farming knowledge, whereas nuclear families lean towards wage-based employment. The findings of the study are aligned with the study of Girdziute et al., (2022) who reported that household size significantly influences labor allocation decisions, with larger households tending to diversify livelihoods to ensure financial stability. The analytical approach employs text queries and matrix coding to visualize thematic analysis, demonstrating that declining community interactions, economic pressures, and technological advancements collectively contribute to the gradual erosion of traditional agricultural knowledge (Kumari et al., 2024). This study suggests that while innovation and market-driven adaptations are inevitable, integrating indigenous wisdom with sustainable modern techniques through education, policy interventions, and intergenerational collaboration could mitigate the loss of traditional knowledge and promote resilient agricultural practices.

CONCLUSION

The study highlights the intricate relationship between socio-economic factors and livelihood choices in both agricultural and non-agricultural sectors. Findings suggest that family education status, primary occupation, landholding size, material possession, and openness to innovation significantly influence agricultural engagement, while education, family size, and family education status drive non-agricultural livelihoods. Innovativeness negatively correlates with both sectors, indicating a shift toward diversified income opportunities. The thematic analysis underscores the ongoing transformation of indigenous agricultural knowledge, driven by education, economic stability, and modernization. The generational divide in knowledge adoption and mass media influence further accelerates this shift. To sustain traditional farming wisdom, integrating indigenous practices with modern techniques through education, policy support, and intergenerational collaboration is essential. By fostering adaptive strategies and knowledge-sharing mechanisms, agricultural resilience can be enhanced, ensuring a balanced approach to modernization and heritage conservation.

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Research Article

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Farm Mechanization and Farmers' Preferences: Evidence from North Bank Plain Zone of Assam

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HIGHLIGHTS

- The average mechanized farm area among the sample farmers was 27.52 per cent. High degree of mechanization was found for post-harvest operation like milling and threshing followed by land preparation.
- Knapsack or power sprayer, portable milling machines, tractor mounted thresher and tractor with rotavator were the most preferred farm machinaries among the farmers
- Farmers' most preferred farm operation for mechanization were irrigation, milling, plant protection, threshing and land preparation.

ARTICLE INFO

Keywords: Farm mechanization, Farmers' preferences, Farm machinery.

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ABSTRACT

The study was conducted during 2022 in the North Bank Plain Zone of Assam to assess the degree of farm mechanization, preferences toward farm machinery and farm operations, as well as factors influencing the extent of farm mechanization. Descriptive research design was followed and a purposive cum stratified random sampling technique was used for selection of 120 farmers as respondents for study. The degree of farm mechanization was recorded from medium to high for the majority of farmers, with an average farm mechanization area of 27.52 per cent. The majority of farmers showed a medium level of preference towards farm mechanization, but knapsack or power sprayer, portable milling machines, tractor-mounted thresher, tractor with rotavators or cultivator were the most preferred farm machineries. Irrigation, milling, plant protection, threshing, and land preparation were the most preferred farm operations for mechanization. Six socio-economic factors, viz. farm size, innovativeness, extension contact, credit availability, training exposures, and preferences for mechanization were positively and significantly contributed around 46 per cent variation of farm mechanization. Governments and non-government organizations should put efforts into promoting farm mechanization through the establishment of a custom hiring center for preferred farm machinery, easy access to government assistance, and strategic mobilization of resource-poor farmers.

INTRODUCTION

Mechanization is regarded as a key solution to the challenges of food insecurity and malnutrition in India, primarily by enhancing agricultural efficiency in the context of a growing population. Farm mechanization, a crucial component of the Green Revolution, marks a significant transition from traditional agricultural practices reliant on human and animal labor to the use of machines for various farming operations. The adoption of mechanization not only improves the timeliness and efficiency of agricultural tasks but also holds the potential to reduce production costs and enhance overall farm profitability. Research conducted in the past has indicated that effective mechanization can result in substantial savings of seeds (15-20%), fertilizer (20-30%), time (20-30%), and labor (5-20%),

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leading to an increase in cropping intensity (10-15%) and overall productivity (15-20%) (Singh, 2008; Tiwari et al., 2017; Tiwari et al., 2019; Mehta et al., 2023). Despite the potential benefits, the level of farm mechanization in India remains relatively low, standing at around 40-45 per cent, in stark contrast to nations like the US and Western Europe with rates as high as 95 per cent, as well as Russia (80%), Brazil (75%), and China (48%) (Mehta et al., 2023). The evolution of power availability per hectare over the years is remarkable, rising from a mere 0.32 KW in 1961-62 to an estimated 5.17 KW/ha in 2032-33 (Tiwari et al., 2017; Tyagi et al., 2010; Singh et al., 2021; Mehta et al., 2023). This transition is reflected in the shift from animate power sources (human and animal labor) contributing 91.35 per cent in 1960-61 to a mere 6 per cent in 2020-21. In contrast, mechanical power sources have surged from 37.80 per cent to 81.15 per cent, while electrical power's share has increased from 2.36 per cent to 19.58 per cent during the same period (Singh et al., 2021). Amidst this context, the state of Assam presents a unique scenario, with mechanization levels lagging behind despite consistent efforts by the government. The farm power availability in 2024 is about 3.126 kW/ha as estimated by the Indian Council of Agricultural Research (ICAR). However, significant disparities exist across the states -Punjab has a farm power availability of 6 kW/ha, whereas northeastern states like Assam and Mizoram have only 1.2 kW/ha and 0.7 kW/ha, respectively (Mehta et al., 2023). The government of Assam has taken proactive steps by implementing central sector schemes aimed at promoting farm mechanization. Nevertheless, the success of these initiatives hinges on the attitudes and preferences of farmers towards adopting new technologies. The adoption or rejection of a technology is significantly influenced by farmer perceptions, attitude, and requirements (Mwangi & Kariuki, 2015). Therefore, to expedite agricultural modernization, understanding farmer preferences towards mechanization and machinery becomes vital for consideration. In light of these considerations, this study was carried out to assess the farmers' level of farm mechanization, preference of mechanization and factors influencing farm mechanization.

METHODOLOGY

The study was conducted in Biswanath and Sonitpur district of Assam during 2022. A descriptive research design was followed to conduct the study. Purposive cum stratified random sampling techniques was followed for selection of districts, sub-divisions, Agriculture Development Officer (ADO) circles, Agriculture Extension Assistant (AEA) Elekas and villages for the study. A total of eight villages- Pormaigauli, Rupkuria, Bakchung, Punioni, Kuwari, Japoubari, Borpothar-1 and Borpothar-4 were randomly selected from eight designated AEA elekas for the study. From each village, 15 farmers were selected using simple random sampling, resulting in a total sample size of 120 farmers for the study. Data for the study were collected through pretested interview schedule with the help of personal interview method.

In order to measure farm mechanization, the following formula was used;

$$FMi = \frac{AMi}{Tai} \times 100$$

Where, FMi is the mechanization index, AMi is the mechanized area and T_{Ai} is the total farm area

In order to assess preferences of farmers towards farm mechanization a total of 24 statements were prepared based on review of literature and consultation with experts. The responses of farmers were collected against each statement by following 5-point responses continuum i.e., strongly agree, agree, undecided, disagree and strongly disagree with respective scores of 5, 4, 3, 2 and 1. Subsequently, based on the responses obtained from the respondents, frequencies and percentages were calculated. The scale value of Farmers' preference towards mechanization and farm operation were calculated by following formula

$$SVP = fx_i \times 5 + fx_i \times 4 + fx_i \times 3 + fx_i \times 2 + fx_i \times 1.$$

In order to assess the level of farmers preferences towards farm machinery, a comprehensive list of farm machinery was prepared in consultation with agriculture development officers and Agriculture engineers. Respondents were asked about which machinery they 'owned', 'hired' and 'not used' accordingly score was assigned as 2, 1 and 0 respectively. Thus, in order to rank the machinery, Total Weighted Score and Mean Weighted Scores was calculated by using the following formula:

$$TWS = f\,xi * 2 + fxi * 1 + fxi * 0$$

Where, TWS = Total weightage score for a machinery, fix = frequency of respondents

$$MWS = \frac{TWS}{N}$$

Where, MWS = Mean weightage score for a machinery, TWS= Mean weightage score for a machinery, N= Total number of respondents. Multiple linear regression analysis was conducted using SPSS to identify the factors influencing farm mechanization. Appropriate statistical techniques were applied for interpretation of data.

RESULTS

Farm mechanization status in study area

The data from Table 1 illustrates that a significant proportion (60.83%) falls within the medium level of farm mechanization followed by high level of farm mechanization among 25 per cent of respondents.

Mechanization of farm operations

From Table 2 it is clear that among the various farm operations, milling was the almost fully mechanized, with mean mechanization value 97.9 followed by threshing (71.5). Field preparation and plant protection were found to be with mechanization index of 48.7 and

Table 1. Distribution of farmers according to the extent of farm mechanization

Mechanization level	Score ranges	Respondents (%)	Mean	SD	CV
Low	21.15-23.60	14.16			
Medium	23.61-29.99	60.83	27.52	03.01	10.93
High	30.00-40.64	25.00			

Table 2. Extent of farm mechanization adopted by farmers

Farm operation	Mean Farm Mechanization Index	SD
Field preparation	48.7	12.4
Transplanting/sowing of seed	3.39	9.8
Irrigation	23.34	39.5
Weeding	2.1	10.8
Plant protection	42.27	29.0
Harvesting	9.8	77.0
Threshing	71.5	29.8
Winnowing	9.2	29.0
Milling	97.9	0.7

42.27, respectively. Irrigation operations display a lower mechanization index of 23.34 per cent. The rest of the farm operation namely transplanting/sowing of seed, weeding, harvesting and winnowing had less than 10 per cent of farm mechanization.

Farmer's preference towards farm mechanization and farm machinery

The degree of preference towards farm mechanization was recorded at a medium level for most farmers (72.50%), followed by a high level of preference for 15.83 per cent of farmers (Table 3). The mean score of 85.67 indicates a medium level of preference towards farm mechanization. The majority of farmers preferred mechanization, which might be due to high labour costs, migration from the agricultural sector to the non-agricultural sector, and also to have less drudgery-prone agricultural practices.

Table 3. Distribution of respondents according to level of preference of farm mechanization

Level of preference	Score ranges	Respondents (%)	Mean score	SD	CV
Low	76.00-79.96	11.67			
Medium	79.97-91.43	72.50	85.67	5.72	6.69
High	91.44-102.00	15.83			

It is observed from Figure 1 that the knapsack or power sprayer had the highest preferences among all the farm machinery and implements. The portable rice milling machine was the farmer's next preferred machinery for milling operation.

Farmers' preference towards tractor-mounted thresher is in fourth position, followed by tractor with rotavator and cultivator. For the rest of the farm machinery, the low level of preference was recorded (Figure 1).

Choices of farm practices for farm mechanization

It is observed from Figure 2 that among all the farm practices majority of farmers preferred that irrigation operations be mechanized, which occupied the first rank, followed by milling. The next preferred farm operation was plant protection. Threshing and land preparations ranked fifth and sixth, respectively, in the preference for mechanization, whereas other operations like transplanting, harvesting, weeding, and nursery bed preparation had less farmers' preference for mechanization.

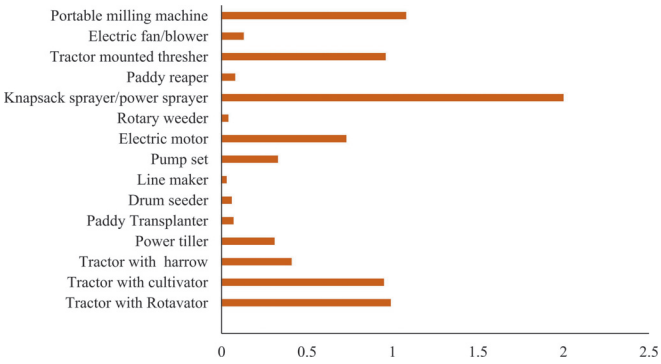

Figure 1. Farmers' preferences towards farm machinery

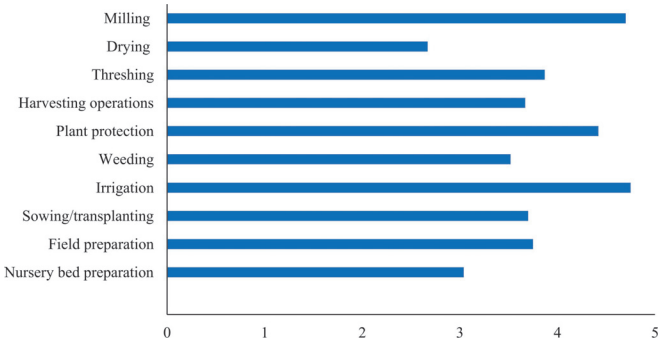

Figure 2. Ranking of farm practices based on the choices of farmers

Factors influencing the extent of farm mechanization

Out of 16 independent variables, only six variables (Table 4) were found to contribute significantly towards the extent of farm mechanization. The variables, *viz.* farm size (x_3), innovativeness (x_8), extension contact (x_9), credit availability (x_{10}), training exposures (x_{14}), and preferences for mechanization (x_{16}) were positively and significantly contributed towards the extent of farm mechanization at the 0.05 level. The value of R^2 (0.46) indicated that six independent variables were found significant in the prediction of the extent of farm mechanization. Similar findings were reported by Abdullah & Samah (2013); Ayandiji & Olofinsao (2015); Mottaleb et al., (2016); Yassing et al., (2016); Kehinde & Adeyemo (2017); Rajkhowa et al., (2020).

DISCUSSION

The level of farm mechanization among the majority of farmers was concentrated in the medium level within the range of 23.61-29.99 per cent, and the average level of farm mechanization among the farmers was recorded at 27.52 per cent. This may be due to fragmented land holdings, lack of availability of farm machinery in their locality, higher hiring charges, and low penetration of government schemes (Rajkhowa et al., 2020; Teja et al., 2021).

Among the various farm operations, more mechanized farm operations were milling and threshing, followed by field preparation and plant protection. Similar findings were also reported from Bangladesh by Adu et al., (2012) & Rahman et al., (2021). The threshing operations trend can be linked to the limited availability of labor, coupled with higher labor wages, encouraging farmers to

Table 4. Influences of selected socio-economic factors on the extent of farm mechanization

	Coefficients	Standard Error	t Stat	P-value
Intercept	1.44	6.32	0.23^{NS}	0.820
Age (x_1)	0.02	0.03	0.43 ^{NS}	0.668
Educational status (x_2)	-0.04	0.15	-0.24 ^{NS}	0.811
Farm size (x_3)	0.41	0.20	2.09*	0.039
Land type (x_4)	0.48	0.34	1.41 ^{NS}	0.162
Occupation (x_5)	0.06	0.22	0.26 ^{NS}	0.798
Annual Income (x_6)	-0.39	0.22	-1.75 ^{NS}	0.084
Farming experience (x_7)	0.01	0.04	0.19 ^{NS}	0.853
Innovativeness (x_8)	0.36	0.16	2.23*	0.028
Extension contact (x_9)	0.37	0.13	2.91*	0.004
Credit availability (x_{10})	0.75	0.15	3.08*	0.003
Mass media exposure (x_{11})	0.15	0.12	1.22 ^{NS}	0.224
Labour availability (x_{12})	-0.01	0.01	-0.75 ^{NS}	0.454
Availability of service centre (x_{13})	-0.88	0.61	-1.44 ^{NS}	0.152
Training exposures (x_{14})	0.85	0.43	2.01*	0.048
Avail of Government scheme (x_{15})	0.30	0.19	1.61 ^{NS}	0.111
Preferences for mechanization (x_{16})	0.25	0.07	3.47*	0.001

* Significant at 0.05 level of probability, NS=Not significant, R^2=0.46

opt for tractor-mounted threshers. These machines are not only cost-effective but also reduce drudgery and save time compared to manual threshing or the use of draught animals (Raina et al., 2021; Hasan et al., 2020; Adu et al., 2012). Transplanting, harvesting, and winnowing operations reported the lowest mechanization rate because of low availability of compatible machinery and lack of skills (Vemireddy & Choudhary, 2023). Some farmers use electric fans or blowers while others opt for threshers, which eliminate the need for winnowing. Low mechanization of harvesting operations was observed which might be due to the unavailability of harvesting machinery, farmers' limited awareness of paddy harvesters, and the high cost associated with such machines (Kavya & Shobharani, 2019; Hasan et al., 2020). Weeding operations exhibit the lowest mechanization rate, because of non-adoption of line transplanting methods.

Majority of farmers preferred farm mechanization because of high labour cost (Buttar et al., 2023; Raina et al., 2021; Tiwari et al., 2017 & Mehta et al., 2023), migration from agricultural sector to the non-agricultural sector, making agricultural practices less drudgery prone (Kavya & Shobharani, 2019; Medeksa, 2018). Farmers preferred farm machinery due to less cost and higher efficiency, lower labour requirements, and the necessity of using quality processed products. (Workneh et al*.,* 2021; Singh et al., 2011). Farmers preferred tractor-mounted thresher as it is less time-consuming, less drudgery prone as compared to manual threshing (Hasan et al., 2020). Reasonable hiring charge for tractor tractor-mounted thresher is another reason for preference. Tractor with cultivator preferred as because of good working efficiency with less hiring cost (Workneh et al*.,* 2021). Machinery in case of irrigation operation like pump set, solar pump, electric motor etc. are preferred by the respondents because of its efficiency and easy availability in time for irrigation (Sarkar et al., 2013; Vemireddy & Choudhary, 2023). Among all the farm practices majority of the respondents prefer, irrigation operation to be mechanized. It's because irrigation is much essential for farming, without irrigation it's not possible to do farming in all season, followed by milling, as milling process is as important as irrigation. Plant protection practices are to be mechanized as spraying of chemicals or pesticide manually in a large field is a laborious and time-consuming work. Threshing operation and land preparation are considered as more drudgery-prone and time-consuming, so there is a need for mechanization. Farmers had the least preference for mechanization of transplanting, harvesting, weeding, and nursery bed preparation, as these operations can be done manually and not much aware about farm machinery related to these operations are the reasons (Vemireddy & Choudhary, 2023).

The linear regression analysis could predict 46 per cent of the variation in the extent of farm mechanization. Variation of farm mechanization among farmers is influenced by the socio-economic characteristics, viz., farm size, innovativeness, extension contact, credit availability, training exposures, and preferences to mechanization of farmers (Yassing et al., 2016; Kisku et al., 2022).

CONCLUSION

The study highlights a considerable variation in the level of farm mechanization among the sample farmers. Results indicate that the majority of respondents fall within the medium mechanization category. This underscores the necessity for greater involvement from both government and non-government organizations to encourage mechanized farming practices among farming communities to ensure sustainable agricultural production. The study's current insights serve as a valuable resource for policymakers, enabling them to formulate targeted strategies to enhance mechanization adoption among farmers. Such initiatives have the potential to revitalize the agricultural sector not only within the study area but also throughout the entire state of Assam.

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Research Article

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Institutional Engagement and Its Role in Livelihood Transformation of Tribal Coffee Farmers in Araku Valley

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HIGHLIGHTS

- Social Network Analysis (SNA) revealed that Naandi Foundation is the central institutional actor driving livelihood transformation in Araku Valley.
- Villages with multi-institutional engagement showed higher improvements in income, skill development, and gender empowerment.
- Collaborative institutional ecosystems enhanced community resilience and participation, moving farmers from subsistence to market-linked organic coffee production.

ARTICLE INFO

Keywords: Araku valley, Coffee farming, Institutional linkage, Social network analysis, Tribal livelihood.

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Informed consent of the participants

ABSTRACT

Institutional engagement plays a critical role in shaping sustainable livelihoods in rural and tribal areas, where access to resources, markets, and services is often limited. The study conducted in 2024-2025 explored the impact of institutional involvement on the livelihood transformation of tribal coffee farmers in Araku Valley, Andhra Pradesh. Adopting an exploratory sequential mixed-method research design, the study surveyed 180 farmers across six villages using structured questionnaires, focus group discussions, and key informant interviews. Data were analyzed using Social Network Analysis (SNA) with UCINET software to map institutional linkages and assess centrality indicators. The findings revealed that the Naandi Foundation was the most influential institutional actor, maintaining strong and consistent linkages across all villages. Villages with higher institutional connectivity, such as Thudumu, Pakanakodi, and Doravalasa, reported significant improvements in income, skill development, gender empowerment, and market access. The convergence of multiple institutions in these areas created synergies that enhanced overall development outcomes. The study highlighted how collaborative institutional ecosystems foster resilience and build local capacity. It demonstrated how inclusive engagement transforms subsistence farming into market-oriented enterprises, providing a scalable model for rural development and emphasizing the importance of institutional coordination for sustainable livelihood outcomes in tribal regions.

INTRODUCTION

In many tribal and remote areas of India, achieving sustainable livelihoods continues to be a major challenge due to limited access to basic infrastructure, markets, and institutional services. These regions often experience a cycle of poverty and underdevelopment, where communities depend heavily on subsistence farming with very few external linkages. In such settings, institutions, whether governmental, non-governmental, or private, can play a transformative role (Singh et al., 2014; Albore, 2018; Singh et al., 2023). Institutional engagement refers to the active involvement of formal organizations in improving the livelihoods of communities

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through support in areas like agriculture, skill development, market access, and social empowerment. When such engagement is consistent, inclusive, and responsive to local needs, it can significantly impact the quality of life in rural and tribal regions. Livelihood transformation involves more than just an increase in income (Shetunyenga, 2024). It includes better access to opportunities, improved capacity of individuals and groups, enhanced participation in decision-making, and more sustainable and secure futures (Gajbhiye et al., 2015; Bennet et al., 2019; Kademani et al., 2020). Institutions are critical in facilitating this transformation by helping communities shift from traditional, subsistence-based practices to more organized, market-oriented, and resilient livelihood systems (Manlosa, 2022). The role of institutions becomes especially important in areas where people have historically been excluded from mainstream development processes (Rout & Patnaik, 2014).

A clear example of this is seen in the Araku Valley of Andhra Pradesh, where tribal farmers have traditionally cultivated coffee using age-old methods. In recent years, the region has undergone a remarkable transformation, largely due to the involvement of multiple institutions working together to support local communities (Karki et al., 2016). Organizations like the Naandi Foundation, the Coffee Board, and several development NGOs have introduced new ideas, practices, and connections that have changed the way coffee is produced, marketed, and valued (Hogg & Joseph, 2013). These efforts have helped tribal farmers shift from growing coffee as a subsistence crop to producing high-quality organic coffee for national and international markets. Beyond the economic impact, institutional engagement has also brought social change (Upendranadh & Subbaiah, 2012). The formation of Self-Help Groups (SHGs), Farmer Producer Organizations (FPOs), and cooperatives has created new platforms for women and youth to take leadership roles and participate in decision-making (Shinogi et al., 2021). Skills training, financial literacy, and exposure to new markets have given many farmers greater confidence and control over their livelihoods. This kind of support has not only increased household incomes but also strengthened community bonds and local governance structures (Das et al., 2025). What makes the Araku experience especially valuable is the way different institutions have worked in coordination rather than isolation. When multiple organizations contribute their strengths in a complementary way, the impact is deeper and more lasting (Hogg & Joseph, 2013). This study aims to understand how such institutional engagement has influenced the livelihoods of tribal coffee farmers in Araku Valley. It identifies the presence, roles, and linkages of various institutions and how they have collectively contributed to changes in income, skills, empowerment, and overall well-being of the community.

METHODOLOGY

This study adopted an exploratory sequential research design to investigate the role of institutional engagement in the livelihood transformation of tribal coffee farmers. An exploratory sequential design is a mixed-methods approach that begins with qualitative data collection and analysis, followed by quantitative methods to build on initial findings. This design was appropriate as it allowed an in-depth exploration of institutional linkages, which was later validated through structured surveys. The research was conducted during 2024–2025 in Araku Valley block of Alluri Seetarama Raju District, Andhra Pradesh. Araku Valley was purposively selected due to its significance in tribal coffee cultivation and the active presence of institutional actors. To ensure representativeness, a random sampling method was used to select six villages that is Gondivalasa, Thudumu, Chinalabudu, Pakanakodi, Doravalasa, and Killoguda. From each village, 30 tribal coffee farmers were randomly chosen, resulting in a total sample size of 180 respondents. A multi-method approach was used for data collection. Primary data were collected through structured questionnaires covering variables such as institutional engagement, presence, perceived support, and linkage strength. The questionnaire was validated through expert review by agricultural extension professionals. Secondary data from journals, reports, and government sources were also reviewed to support and contextualize findings. Data analysis involved Social Network Analysis (SNA) to examine institutional linkage patterns among farmers and organizations. UCINET software was used to generate network maps and analyze key metrics (Kumari et al., 2024). Centrality indicators such as degree, betweenness, and closeness were computed to determine each institution's influence within the network. Degree centrality reflected direct connections, betweenness indicated intermediary roles, and closeness measured efficiency of access to others in the network. A heat map was developed to visually represent the intensity of institutional engagement across villages. Color gradients illustrated the variation in institutional presence and connectivity, offering clear insights into areas with stronger or weaker institutional ecosystems. These analytical tools enabled a comprehensive understanding of how institutional collaboration influences livelihood outcomes among tribal coffee farmers in Araku Valley.

RESULTS

SNA: Institutional engagement

The SNA (Figure 1) clearly showed that dense respondent clusters around each village node, Naandi Foundation as the central

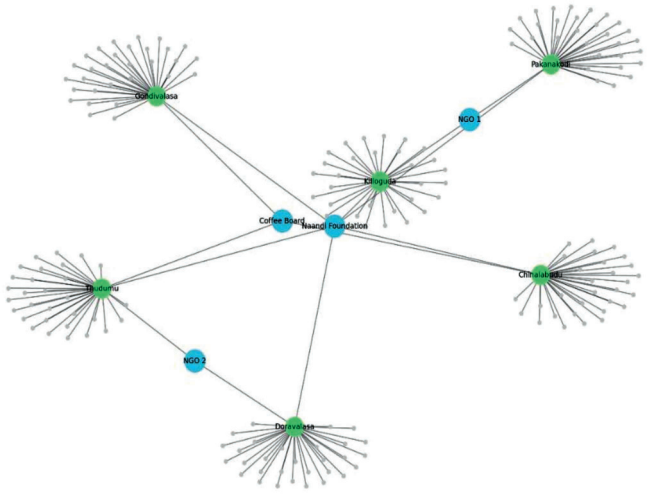

Figure 1. SNA: Institutional Engagement and its role in Livelihood Transformation

institutional hub, connected to all villages and other institutions, had a more selective village-level engagement, indicating the multi-tiered structure of support in livelihood transformation.

Institutional presence

Table 1 captured the presence and intensity of four key institutional actors, Naandi Foundation, Coffee Board and two simulated NGOsacross the six study villages in Araku Valley. It showed that while the Naandi Foundation was present in all six villages (with high engagement in most), the other institutions had a selective and targeted reach. Naandi Foundation played a central role in every village, especially in Pakanakodi, Doravalasa, and Thudumu, where their activities included training, direct procurement of beans, branding of Araku Coffee, and facilitating SHGs. The Coffee Board mainly operated in Gondivalasa, Thudumu, and Chinalabudu, focusing on extension services and subsidy linkage. NGO 1 had a focused presence in Pakanakodi and Killoguda, where they provided skills training and women empowerment programs. NGO 2 supported Doravalasa and Thudumu with health outreach and nutrition awareness programs. The last column quantified the number of active institutions per village. Thudumu stood out with engagement from three institutions, suggesting a more supportive ecosystem compared to Gondivalasa and Chinalabudu, where only two institutions were present.

Perceived impact of institutional engagement

Table 2, reflected respondent perceptions, likely gathered through FGDs or ranking exercises, about how institutional presence had affected different aspects of livelihood: Income and Market Linkage: Villages like Pakanakodi and Doravalasa reported high impacts due to organized marketing and premium pricing of Araku Coffee. This aligned with Naandi Foundation's strong intervention in these areas. Gender Empowerment: SHG involvement, training, and financial literacy programs led to a noticeable increase in women's participation in economic and household decisions, particularly in Killoguda, Doravalasa, and Pakanakodi. Skill Development: Focused training efforts by NGOs and the Coffee Board (in Thudumu and Chinalabudu) enhanced capabilities in post-harvest handling, organic farming, and enterprise development. Overall Livelihood Impact: Villages with diversified and sustained institutional engagement, namely Thudumu, Pakanakodi, and Doravalasa, showed the highest perceived transformation, indicating that institutional synergy played a vital role in holistic rural development.

Tables 1 and 2 summarized how institutional presence correlated with village-level transformations. Villages with higher institutional overlap (like Thudumu, Doravalasa, Pakanakodi) showed higher overall livelihood impact, particularly in gender empowerment and market access.

Table 1. Institutional Presence across villages

Village	Naandi Foundation	Coffee Board	NGO 1	NGO 2	No. of Institutions Present
Gondivalasa	√	√	×	×	2
Thudumu	√	√	×	√	3
Chinalabudu	√	√	×	×	2
Pakanakodi	√	×	√	×	2
Doravalasa	√	×	×	√	2
Killoguda	√	×	√	×	2

Institutional linkages

In SNA, centrality indicators were used to quantify the relative importance or influence of actors (institutions, in this study) within a network. The three key centrality measures used in this research are degree centrality, betweenness centrality and closeness centrality. Degree centrality refers to the number of direct connections an actor has with others in the network. A higher degree centrality indicates that the institution is more active or visible in the network, engaging with multiple actors directly. Betweenness centrality measures how often an actor lies on the shortest path between other actors. It reflects the institution's role as a bridge or intermediary, suggesting its potential control over the flow of information or resources between disconnected actors. Closeness centrality indicates how close an actor is to all other actors in the network based on the shortest paths. A higher closeness value suggests that the institution can quickly interact or disseminate information across the network, demonstrating accessibility and influence. These indicators collectively help identify which institutions are central, influential, or strategically positioned within the network, thereby informing the understanding of institutional engagement in livelihood transformation.

Table 3 showed that Thudumu ranked highest across all centrality indicators, making it the most influential node for institutional interactions. All villages showed strong linkage with Naandi Foundation, confirming its pivotal role in regional livelihood development. Villages that had three institutional linkages demonstrated higher centrality and stronger transformation outcomes, supporting the idea that multi-actor synergy enhanced developmental reach.

Figure 2 showed the heatmap of institutional impact on tribal livelihood transformation, an innovative visualization that illustrated

Table 2. Perceived Impact of Institutional Engagement on Livelihood Transformation (Village-wise)

Village	Perceived Impact on Income	Market Linkage	Gender Empowerment	Skill Development	Overall Livelihood Impact
Gondivalasa	Medium	Low	Medium	Low	Moderate
Thudumu	High	Medium	High	High	High
Chinalabudu	Medium	Medium	Medium	Medium	Moderate
Pakanakodi	High	High	High	High	High
Doravalasa	High	High	High	Medium	High
Killoguda	Medium	Medium	High	Medium	Moderate

Table 3. Summary of Centrality Scores and Institutional Linkages

Village	Degree Centrality	Betweenness Centrality	Closeness Centrality	No. of Institutions Linked	Institutional Partners
Thudumu	0.1746	0.2992	0.3810	3	Naandi Foundation, Coffee Board, NGO 2
Gondivalasa	0.1693	0.2946	0.3795	2	Naandi Foundation, Coffee Board
Pakanakodi	0.1693	0.2966	0.3795	2	Naandi Foundation, NGO 1
Killoguda	0.1693	0.2966	0.3795	2	Naandi Foundation, NGO 1
Chinalabudu	0.1693	0.2946	0.3795	2	Naandi Foundation, Coffee Board
Doravalasa	0.1596	0.2902	0.3779	2	Naandi Foundation, NGO 2

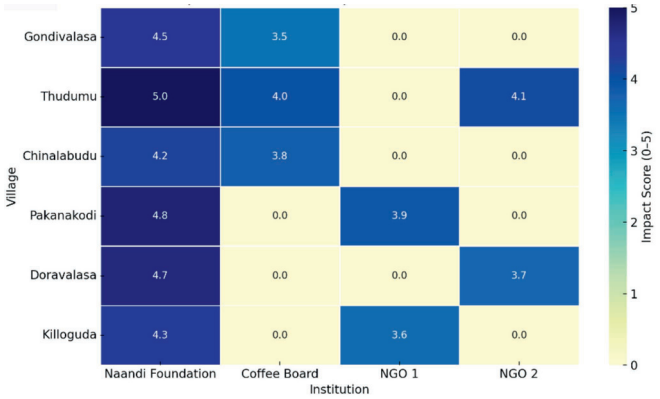

Figure 2. Heat map of Institutional Impact on Tribal Livelihood

the intensity of institutional impact across each village (darker shades = higher impact), Naandi Foundation's consistently high scores in all villages, the selective but targeted presence of Coffee Board, NGO 1, and NGO 2. This heatmap made it easier to compare institutional performance and coverage across multiple villages at a glance.

DISCUSSION

The Social Network Analysis (SNA) of the study indicated that the institutional landscape of the tribal coffee farming communities in the Araku Valley was highly clustered and interconnected. The results showed that institutions significantly influenced the directions of rural development, and the Naandi Foundation emerging as the most significant node in the network. It consistently scored highest across the three centrality metrics that is degree, closeness, and betweenness, highlighting its extensive involvement and critical role in bridging villages with other institutional actors. High levels of institutional connectivity in villages like Thudumu, Pakanakodi, and Doravalasa were associated with a positive impact on important aspects of livelihood like gender empowerment, income enhancement, market integration, and skill development. These findings were supported by Mehta et al., (2023) who found that institutional capital functions as a basic resource that communities use to obtain access to opportunities, resources, and knowledge. The findings were also consistent with the framework for sustainable livelihoods, which argues that access to institutional support strengthens the five primary livelihood assets: natural, financial, physical, social, and human (Natarajan et al., 2022). The study also align with Kademani et al., (2025) whereas, targeted interventions across different aspects of support, potentially leading to more efficient allocation of resources was advocated. The study's heatmaps and network visualizations further illustrated that villages with stronger institutional presence acted not merely as beneficiaries, but as bridging nodes within the system. These intermediary villages facilitated the diffusion of knowledge, innovations, and best practices both vertically and horizontally, increasing the effectiveness and equity of development interventions. This dynamic was particularly evident in Thudumu, which recorded the highest centrality scores and the most substantial improvements in livelihood outcomes. Notably, Thudumu was supported by three institutions. The Naandi Foundation's role was particularly multifaceted. Beyond its traditional function of aggregating coffee beans, the organization also acted as a value-chain enabler by providing training in sustainable agricultural practices, ensuring quality control, connecting farmers to premium markets, and supporting direct marketing channels for Araku Coffee. Assessments by KPMG (2018) and documentation from the Coffee Board of India (2017) corroborated these contributions, emphasizing Naandi's crucial role in converting subsistence farming into globally recognized organic coffee production. This multi-layered, cooperative institutional ecosystem effectively transformed tribal farmers from passive recipients to active participants in social and economic change. Through collaborative platforms, institutional partnerships, and information exchange, these actors worked together to improve socioeconomic resilience, foster community cohesion, and build local capacities. The Araku model demonstrated how strategic and inclusive institutional engagement could serve as a replicable model for sustainable rural development in underprivileged areas.

CONCLUSION

This study indicates that institutional engagement is crucial to improving the livelihoods of tribal coffee farmers in the Araku Valley. It illustrates how villages with greater levels of institutional connectivity see notable improvements in income, market access, skill development, and gender empowerment. The findings show that multi-institutional partnerships create a favorable atmosphere where local communities actively participate in their own development. The primary institution plays a crucial role in providing training, quality control, and access to global markets, all of which contribute to the sustainability of rural livelihoods. In addition to receiving various forms of financial assistance, villages with strong institutional ties can also function as knowledge centers in the region. The study confirms that integrated institutional networks are necessary for inclusive and sustainable rural development. These findings have important policy and practice implications and provide a replicable model for enhancing livelihood outcomes in other marginalized and tribal areas.

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Rural Teachers' Quality of Life Through Physical, Psychological, Social, and Environmental Lenses

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HIGHLIGHTS

- Teachers aged over 50 reported significantly better environmental QoL (p=0.001).
- Psychological health varied significantly by caste, with OBC teachers scoring highest (p=0.001).
- Postgraduate teachers had significantly higher environmental QoL scores than those with only UG degrees (p=0.004).
- Married teachers showed significantly better psychological and environmental QoL than unmarried ones (p=0.024, p=0.00).
- Nuclear families were associated with significantly better QoL across all four domains (p<0.05).

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Keywords: Quality of life, Rural teachers, Rural school, Education, Socioeconomic status.

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ABSTRACT

The paper discusses rural senior secondary school teachers' QoL. Teachers play an important role in community development by driving economic growth, social stability. The objective of the study was to evaluate the QoL of rural SES teachers and compare it with socio-demographic factors. The study was conducted in 2022 among 185 teachers. The selection of the teachers was made through multistage sampling from Kashi Vidyapeeth and Chiraigaon block of Varanasi. The results show that age, caste, marital status, years in service, SES, family type, and education significantly impact specific QoL domains. Teachers aged >50 years reported the highest Environmental QoL scores (57.40± 20.23, p=0.001). The caste also played a role, with OBC teachers having the highest Psychological Health scores (55.78±14.71, p=0.001). Marital status was significant in Psychological Health (p=0.024) and environmental QoL ($p < 0.001$), with married teachers scoring higher. Teachers with >5 years in service had better Psychological Health ($p = 0.026$) and environmental QoL ($p < 0.001$). Family type also influenced QoL, with nuclear families scoring significantly higher across all domains ($p < 0.05$). whereas gender, religion, occupation, area of residence, and house status did not show significant differences ($p > 0.05$).

INTRODUCTION

Teachers, the most important human resources. The nature and qualities of any educational structure depend generally on their teacher's work. It has been vastly stated that educating is one of the most stressful occupations in the world. Today, in many associations, teachers are not happy with their job (Albertson & Kagan, 1987). They play an important role in developing that section of country education need first for development then anything. They are the light source for students who are deprived of resources and lack of guidance. Teaching refers to the process of conveying knowledge and skills from a teacher to their students. It contains the activities of educating or instructing. It is an act or experience that has a formative effect on the mind, character or physical ability of an individual. Quality of Life (QoL) is the Individuals satisfaction (or dissatisfaction) with the cultural or intellectual conditions under which they are living. It is one of the essential aspects of individual's life that impacts the person's

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performance and progress. It affects both the personal and professional parts.

The concept of quality of life (QoL) has emerged as a critical domain of research, particularly in understanding the well-being of individuals across various socio-economic and cultural settings. QoL encompasses multiple dimensions, including physical health, psychological well-being, social relationships, and environmental conditions, which collectively contribute to an individual's overall satisfaction and productivity. Among rural populations, where access to resources and infrastructure is often limited, the QoL holds profound significance, particularly for educators who play a pivotal role in shaping the community's future. In our previous study we have also observed that resource for online education was limited to rural students, many students lacked prior knowledge of online classes, most participated encountered various problems, especially with device and internet connectivity (Mishra & Kumari, 2024b). The QoL for teachers in rural areas is crucial for several reasons, as it directly impacts the education system and the overall development of rural communities. Rural teachers often face significant challenges that affect their QoL, including low pay, poor living conditions, heavy workloads, and limited professional development opportunities (Leech et al., 2022). These factors contribute to the shortage of high-quality teachers in rural areas, as many teachers seek employment in urban settings with better remuneration and living standards. The disparity between urban and rural areas in terms of QoL can lead to greater depression among the rural population, including teachers (Mitchell et al., 2022).

Interestingly, the QoL in rural areas is not only important for teachers but also for the entire community. Keeping the settings of rural school in mind, it's necessary to study the QoL of teachers at rural schools. The study aimed at assessing the QoL of rural secondary school teachers. The study provides an opportunity for further research across QoL of rural primary school teachers to uncover the possible differences or similarities that may be present.

METHODOLOGY

The research design and tools used in this study closely followed those outlined in our earlier work on QoL of students (of class 11th and 12th) in rural senior secondary schools (Mishra & Kumari, 2024a). The study focused on teachers working in senior secondary government schools in rural areas of Varanasi district. Teachers from convent and private schools were excluded. A descriptive method was used to conduct the present study, and survey-type research was conducted through the questionnaire. The sample was selected using a multistage sampling technique. First, the blocks Kashi Vidyapeeth and Chiraigoan were selected randomly from eight blocks of Varanasi district (Arajiline, Baragaon, Chiraigaon, Cholapur, Harhua, Kashi vidyapeeth, Pindra and Sewapuri). Thereafter, by simple random sampling, ten co-educational secondary government schools were chosen from these two blocks. Teachers from these selected schools formed the sampling frame. This study was conducted in the year 2022, and the sample size for the study was calculated to be 185 teachers (both male and female teachers included) aged between 30 and 50 years (M = 36.94, SD= 8.81), selected using Yemen's formula. They were briefed about the purpose beforehand and requested to provide informed consent. Confidentiality and anonymity of responses were assured. Data were collected using a structured questionnaire, which included demographic and socio-economic status information and the World Health Organization's Quality of Life (WHOQOL-BREF, 2012) tool. The WHOQOL-BREF is a widely used standardized instrument comprising 26 items that assess QoL across four domains that are physical health, psychological health, social relationships, and environmental health. Each item is rated on a 5-point Likert scale, with higher scores indicating better perceived quality of life. The two general items measuring an individual's overall perception of QoL and health were not included in the present domain-wise analysis to maintain focus on the specific, measurable domains of the instruments. These global indicators may be explored separately in supplementary reporting. The collected data was analyzed in the SPSS 25 software. Frequency, percentage, mean, and standard deviation was calculated, and chi square test was applied to assess the associations between demographic variables and QoL domains. The p-value was considered statistically significant at the 0.05 level.

RESULTS

The results regarding the QoL of rural teachers about various socio-economic factors are presented in this section in four parts. The first table shows the association between teachers' gender and age with Quality of Life. The second table presents the association of religion, caste with QoL. The third table shows the association of educational qualification, marital status, occupation, and years spent in service with QoL, and at last, the fourth table highlights the association of area of residence, socio-economic status, family type, and house status with QoL.

Table 1. Association of Gender and Age of the Teachers with Quality of Life (QoL)

Variable	Category	PQ	PsychQ	SRQ	EnvQ
Gender	Male	47.63±13.04	53.00±15.47	63.87±17.39	49.12±16.97
	Female	44.82±12.55	49.58±15.02	66.11±17.14	46.19±12.23
	t value	1.39	1.42	-0.83	1.19
	P value	0.167	0.158	0.410	0.234
Age	<=30 years	47.21±11.23	51.83±15.20	65.67±17.54	42.62±14.19
	31-50 years	45.90±13.23	50.97±15.27	64.08±17.14	49.05±14.56
	>50 years	50.37±15.00	57.67±15.97	64.91±18.33	57.40±20.23
	F value	1.03	1.56	0.149	7.097
	P value	0.360	0.212	0.862	0.001*

PQ: Physical health; PsychQ: Psychological health; SRQ: Social relationship; EnvQ: Environment

Table 1 shows that there was no significant difference observed between males and females teachers across various aspects of QoL. However there was a significant difference was found in the Environmental domain of QoL across different age groups (F value = 7.097, p = 0.001*), with older individuals reporting higher scores, which indicates a more positive perception of their environmental QoL than younger individuals.

Table 2 shows no significant difference for the Physical domain, Psychological domain, Social Relationship domain, and Environmental domain for the religion. Similarly, no significant difference for the Physical domain, Social Relationship domain, and Environmental domain for the caste category. However, the psychological domain varied significantly between the caste categories. The mean psychological score in the general caste category was 46.13±13.94, for the OBC caste was 55.78±14.71, and for the SC/ST caste was 51.70±16.30.

Table 3 shows that there were no significant differences in the Physical, Psychological, and Social Relationship domains among the different education levels of the teachers. However, both the Psychological domain and Environmental domain differed significantly based on marital status. Psychological domain for married teachers was reported high (53.50±15.63) compared to unmarried teachers was (47.88±14.04). Similarly, the Environmental domain for married teachers was high (52.04±15.36) than for unmarried teachers (38.56±11.69). there is no significance difference for the Physical domain, Psychological domain, Social Relationship domain and Environmental domain for the occupation of the teachers. There is no significance difference for the Physical domain, Social Relationship domain for the year of service of the teachers however Psychological domain and Environmental domain varied significantly, indicating an association between length of service and these aspects of Quality of Life

Table 4, the psychological domain of quality of life, shows the significant difference across socio-economic status of the teachers. Psychological domain for the Class I was low (48.53±13.92), and progressively high in Class II (53.04±15.11), Class III (60.18±13.87), Class IV (55.00±17.76), and Class V (59.09±19.52), showing a positive trend with increasing socio-economic class. there is a significant difference for, Physical domain, Psychological domain, Social Relationship domain, and Environmental domain for the family type of the teachers, which suggest that family type plays a meaningful role in influencing these dimensions of teachers' Quality of Life.

Table 2. Association of Religion and caste of the teachers with Quality of Life (QoL)

Variable	Category	PQ	PsychQ	SRQ	EnvQ
Religion	Hindu	46.62±13.00	52.04±15.44	64.74±17.39	48.33±15.64
	Muslim	52.38±2.06	43.06±6.36	55.55±4.81	38.54±11.83
	t value	-0.76	1.00	0.91	1.08
	P value	0.446	0.317	0.363	0.281
Caste	General	44.71±13.10	46.13±13.94	60.41±17.28	48.83±15.15
	OBC	47.31±13.73	55.78±14.71	67.16±17.88	47.13±15.81
	SC	48.13±10.87	51.70±16.30	64.96±15.41	49.36±16.04
	F value	1.03	7.10	2.62	0.363
	P value	0.358	0.001*	0.075	0.696

PQ: Physical health; PsychQ: Psychological health; SRQ: Social relationship; EnvQ: Environment

Table 3. Association of Education, Marital Status, Occupation and Service Years with QoL

Variables	Category	PQ	Psych	SRQ	EnvQ
Education	UG	46.43±10.59	48.61±6.80	70.83±8.74	29.68±4.30
	PG	53.36±9.98	55.63±15.66	67.16±18.03	43.38±12.49
	Professional	46.03±13.12	51.62±15.56	64.09±17.46	49.36±15.68
	F value	2.52	0.66	0.64	5.75
	P value	0.083	0.516	0.527	0.004*
Marital status	Married	46.80±13.36	53.50±15.63	64.01±17.39	52.04±15.36
	Unmarried	46.50±11.87	47.88±14.04	66.04±17.13	38.56±11.69
	t value	0.15	2.28	-0.72	5.75
	P value	0.883	0.024*	0.474	0.00*
Occupation	Govt. Service	45.99±14.09	49.68±15.02	64.38±17.83	48.87±15.78
	Private Service	47.41±11.70	54.03±15.47	64.80±16.85	47.51±15.51
	t value	-0.746	-1.941	-0.168	0.591
	P value	0.456	0.054	0.867	0.553
Years Spent in Service	<=5 years	45.36±12.17	48.57±14.53	63.80±18.78	41.14±12.01
	>5 years	47.49±13.31	53.78±15.57	65.04±16.46	52.17±16.06
	t value	-1.08	-2.24	-0.47	-4.90
	P value	0.283	0.026*	0.642	0.000*

PQ: Physical health; PsychQ: Psychological health; SRQ: Social relationship; EnvQ: Environment

Table 4. Association of area of residence, SES, family type and house status with QoL

Variables	Category	PQ	Psych	SRQ	EnvQ
Area of residence	Urban	47.14±13.29	51.83±15.16	64.55±17.57	49.21±15.66
	Rural	45.58±11.92	52.04±16.05	64.70±16.71	45.46±15.34
	t value	0.73	-0.08	-0.05	1.46
	P value	0.465	0.935	0.957	0.146
SES (socio-economic status)	Class I	44.77±12.79	48.53±13.92	62.63±17.79	47.41±14.67
	Class II	47.78±12.94	53.04±15.11	68.01±16.84	50.16±16.20
	Class III	48.41±15.11	60.18±13.87	69.44±17.61	48.43±14.93
	Class IV	48.75±11.94	55.00±17.76	63.75±15.82	46.87±17.61
	Class V	54.22±9.42	59.09±19.52	64.39±15.85	50.28±20.89
	F value	1.78	3.54	1.05	0.29
	P value	0.13	0.008*	0.383	0.883
Family type	Joint	43.27±11.54	44.67±13.44	58.33±17.48	43.13±11.94
	Nuclear	48.42±13.26	55.44±15.05	67.67±16.41	50.65±16.63
	t value	-2.59	-4.47	-3.56	-3.15
	P value	0.010*	0.000*	0.000*	0.001*
House status	Rent	48.39±12.64	55.31±16.20	64.87±17.58	51.47±17.68
	Own	46.08±13.01	50.59±14.90	64.49±17.24	46.92±14.64
	t value	1.09	1.88	0.13	1.78
	P value	0.279	0.062	0.894	0.077

PQ: Physical health; PsychQ: Psychological health; SRQ: Social relationship; EnvQ: Environment

DISCUSSION

Studies on QoL of rural teachers are scarce(Garcia et al., 2008; Oliveira et al., 2012; Oliveira Filho et al., 2012; Silvério et al., 2010) among primary and secondary education teachers, studies on QoL present conflicting evidence regarding gender differences. Some results show a lower perception of QoL among female professionals (Tabeleao et al., 2011) while other find no difference in QoL according to gender (Penteado & Pereira, 2007; Pereira et al., 2013). Despite extensive research on teachers' well-being, the QoL of rural teachers remains an underexplored area in the existing literature. The investigation on QoL is of interest globally due to more concerns being put on becoming healthy, physically and mentally.

The study shows that QoL scores varied widely. Gender did not exert a significant influence on these dimensions of QoL within this specific population. Male teachers scored significantly higher in the domains of Physical health (sig.=0.000) (Zivkovic et al., 2024). Age of teachers shows a significant difference in the Environmental QOL (EnvQ) domain (p=0.001*), with teachers aged > 50 years reporting the highest scores, and other domains were non-significant. This could be because teachers in this age group have less family related responsibility. They get experienced in managing stress and adapting to challenging environment as they develop resilience and coping mechanisms, which helps them in dealing with their environment more positively, whereas religion did not have a substantial impact on rural teacher's perceived QoL. Rural teachers from the OBC category have a significant difference in psychological health.

The study shows that education and QoL among teachers in rural India significantly differ in the Environmental QoL (EnvQ) domain (p = 0.004), with teachers holding professional qualifications reporting the highest scores, likely due to better job opportunities, income, and exposure to urban resources. However, no significant differences were found in Physical Health (PQ), Psychological Health (PsychQ), and Social Relationships (SRQ) domains. This may be due to shared rural challenges, such as limited healthcare access, job-related stress, and strong community ties, which affect individuals similarly regardless of education level. These findings highlight that while higher education improves environmental conditions, it does not necessarily enhance health or social well-being in rural contexts. Whereas most of the teachers had a graduate degree and had low scores in the social relations domain (Santos et al., 2021; Guerreiro et al., 2016). This study shows that married teachers have significantly PsychQ and a highly significant EnvQ than unmarried teachers. Marriage brings emotional support, companionship, and stability, which contribute to better psychological and environmental benefits. Previous studies found marital status to be significantly associated with teachers' QoL, (Khan & Ahmad, 2018; Mojgan Kasaee et al., 2015; Santos et al., 2021).

Government teachers and private/contractual teachers have similar Qol, although some studies reported that workload and type of employment significantly affect the physical and social relationships domains (Santos et al., 2021). Similarly, another study found that teachers with higher workload had worse QoL scores and contracted teachers with fewer hours had higher scores. (Pereira et al., 2014a). Teachers with more than five years of experience had significantly better scores in PsychQ (p = 0.026) and EnvQ (p = 0.000), suggesting that experience contributes to psychological stability and improved living conditions. However, previous studies have reported conflicting findings that teachers with more years of service reported lower QoL indices (Pereira et al., 2014b; Santos et al., 2021). Significant difference was found in PsychQ (p=0.008) with higher SES classes III, IV, and V reporting better psychological well-being. Teachers with higher SES often experience better QoL which can enhance their teaching quality and effectiveness (Lutfiu & Hoxha, 2024), this finding is supported by other studies that

linked SES with teaching quality and job satisfaction(Tavares etal., 2015; Dalton Sangma & Subudhi, 2022; Jayasingh et al., 2022; Gupta & Sharma, 2020). Spending time with family strongly correlates with all aspects of teachers' QoL(Adhiya & Gawali, 2022). This study shows that teachers from nuclear family reported significantly better Qol across all domains ($p<0.05$) which indicate that nuclear family structure provide better psychological and social well being possibly due to greater independence and financial stability. In contrast, other studies have found that teachers from joint families have higher well-being than teachers from nuclear families (Lata, 2024).

CONCLUSION

The study provides valuable insights into the QoL of Rural teachers and highlights the significant influence of demographic and socio-economic factors. Age, Caste, marital status, year in service, SES, family type, and education level were found to impact specific QoL domains. Teachers above 50 years reported the highest Environ QoL scores while OBC teachers had the highest Psycho health scores. the other way around, gender, religion, occupation, area of residence, and house status did not show significant differences. These findings show the crucial role of psychological and environmental factors in shaping teachers' wellbeing. The study emphasizes the need for interventions that consider socioeconomic realities, which ensure a more supportive work environment for teachers in rural areas. Improving living conditions and providing professional development opportunities are essential steps in attracting and retaining high-quality teachers in rural settings.

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Research Article

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Effectiveness of Climate Resilient Interventions on Performance of Dairy Animals in Karnal District of Haryana

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HIGHLIGHTS

- Significant differences were observed in the productive and reproductive performance of dairy animals between NICRA beneficiary and non-beneficiary villages.
- In beneficiary villages, both indigenous and crossbred cattle showed higher levels of average daily milk yield, peak yield, lactation yield, as well as lactation length.
- In beneficiary villages, buffalo also showed increased average daily milk yield, peak yield, lactation yield, as well as lactation length.
- Family education, experience, and participation in extension activities were important factors that affected productive and reproductive performance.

ARTICLE INFO

Keywords: Effectiveness, Climate change, Dairy animals, Performance, Intervention.

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ABSTRACT

To promote climate-resilient agriculture, the Indian Council of Agricultural Research (ICAR) initiated the National Innovations in Climate Resilient Agriculture (NICRA) project. In light of this context, the current study was undertaken in 2022 to assess the effectiveness of technological interventions on the reproductive and productive performance of dairy animals. This study was conducted in the Karnal district of Haryana, which was selected purposively. A sample of 120 respondents was selected, comprising 60 individuals from three NICRA beneficiary villages and 60 from three non-beneficiary villages. Using the Mann-Whitney U test, a significant difference was observed in the productive and reproductive performance of dairy animals. In the beneficiary villages, indigenous cows showed an improvement in both average daily milk yield and lactation yield. Among crossbred cows, there was a positive increase in average daily milk yield, peak yield, lactation yield, and lactation length. Similarly, buffaloes owned by beneficiary farmers exhibited enhanced peak yield, daily milk production, and overall lactation yield. Correlation of socio-economic variables like family education, experience, and participation in extension activities showed a positive correlation towards the productive parameters and a negative correlation towards inefficiencies of reproductive parameters, indicating their enhancing influence on dairy animals.

INTRODUCTION

The foundation of the Indian economy is the agriculture sector, which accounted for 18 per cent of the country's GVA in the financial year 2024-2025 (PIB, 2025). India is the world's largest producer of milk, demonstrating its dominance in the production of agricultural goods (Economic Division, 2024). In the Indian economy, the livestock industry is a significant subsector of

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agriculture. The amount of milk produced in 2022–2023 and 2023–2024 was 230.6 million tonnes and 239.3 million tonnes, respectively, representing a 3.77 per cent annual rise. Approximately 471 grams of milk per day was available per person in 2023-24 (NDDB, 2025). The livestock sector's contribution to the Gross Value Added (GVA) is increasing, highlighting the role of dairying as a driver of social change in India. Projections reveal that India's milk production will increase from 239.1 million tons in 2024 to 321.4 million tons in 2033 (Jirli et al., 2025). This decentralized and small-scale dairy farming model contrasts sharply with developed nations, where specialized dairy farming is more prevalent (Basic Animal Husbandry Statistics, 2020).

Haryana ranks second in the country for per capita milk availability (Basic Animal Husbandry Statistics, 2020). Climate change has deteriorating impacts on livestock production both directly and indirectly. There are various prominent direct consequences of climate change on dairy cattle (Malarkkannan & Kathirchelvan, 2017). It has been projected project the losses to milk production on account of heat stress was 377 thousand tonnes, which translates to a loss of 12.44 billion Indian rupees (Choudhary & Sirohi, 2022). Thus, there is an urgent requirement to bring the focus to climate-resilient production techniques in the dairy sector. The primary objective of climate resilience efforts is to address climate variability by enabling systems to absorb stress, maintain functionality under adverse climatic conditions, and adapt in ways that enhance long-term sustainability. A large share of farmers believe climate change to be anthropogenic as well as naturogenic (Kumar & Saxena, 2024), thus implying they have a basic understanding of the scenario. So, there is a need to reduce the impact of climatic stress, for which it is crucial to adopt effective mitigation technologies, such as developing climate-resistant crop and livestock breeds. In support of climate-resilient agriculture, the Indian Council of Agricultural Research (ICAR) launched the National Innovations in Climate Resilient Agriculture (NICRA) project in 2011. NICRA provides inputs and services to rural areas. In service, animal health camps, kisan gosthi, scientist-farmers session, exposure visits, and advisory services are provided. Additionally, mineral mixture, bedding material, endo and ecto parasite control measures, and dairy animal health kits are provided to farmers in form of inputs. This initiative aims to enhance the adaptability of Indian agriculture including livestock to climate change.

METHODOLOGY

The present study was conducted in the specifically selected Karnal district of Haryana with an objective to assess the effectiveness of technological intervention on performance of dairy animals. This selection was based on the fact that NICRA project was implemented in seven villages of Karnal district. As part of the sampling design, three of these villages were purposively selected for this study. Three categories of milch animals-indigenous cows, crossbred cows, and buffaloes were considered. The average milk yield of each animal during the lactation period was recorded for each respondent. To assess the productive performance and reproductive performance of dairy animals, specific criteria were used as indicated:

Parameters under productive performance were as follows:

Peak yield (PY): It was measured as the highest milk produced by the milch animal in its lactation length, expressed in litres.

Average daily milk yield (ADMY): It referred to the average milk yield of an animal during lactation. This was measured in litres/day by using the following formula:

$$\text{Average milk yield (lit/day)} = \frac{\text{Lactation yield}}{\text{Lactation length}}$$

Lactation length: It referred to the number of days the cow or buffalo remained in milk from the date of calving to the date of drying, expressed in days or months.

Lactation length = Total days a dairy animal remained in milk

Lactation milk yield: The average total quantity of milk provided by an animal in its lactation period expressed in litres and calculated by the following formula:

Lactation milk yield = ADMY × Total Lactation Length

Parameters under reproductive performance were as follows:

Age at first calving: The actual age of the animal at the time of first calving, expressed in months.

Service per conception: Average number of insemination or natural service required by an animal to become pregnant.

Calving interval: The period between two successive calvings i.e., the period between the calving of the first calf to the calving of immediate next calf and was expressed in days.

A pre-tested structured interview schedule was used to collect data and ensure consistency in data collection. The data were collected between February 2022 and May 2022. 60 farmers were randomly selected from the beneficiary villages and 60 non-beneficiary farmers were selected from non-beneficiary villages randomly, where selection criteria was the farmers should have minimum five dairy animals and at least five years' experience in dairying. So a total of 120 respondents were the main contributors of primary information for investigation. Extent of significant difference of control group and treatment group were assessed using Mann-Whitney U test, and to understand the association of socio-economic variables with various performance parameters, correlation coefficient was used.

RESULTS

The average number of buffaloes, indigenous and crossbreed cattle present in both beneficiary and non-beneficiary households are indicated in Table 1, expressed in standard animal unit. All the parameters of productive and reproductive performance were measured as average value taken from each household as indicated

Table 1. Average number of dairy animals present in households

Average number of dairy animals (in SAU)	Beneficiary farmers (n=60)	Non beneficiary farmers (n=60)
Indigenous cattle	1.28	1.58
Crossbred cattle	4.42	3.71
Buffaloes	2.61	3.83

by the respondents. Thus, unit of analysis is household level and sample size is same for all the parameters and all types of dairy animals.

Productive performance

The data in Table 2 and Figure 1 shows that the average of peak milk yield of indigenous cows in beneficiary villages was approximately 8 litres, compared to 6.52 litres in non-beneficiary villages. For crossbred cows, the peak yield was 15.21 litres in beneficiary areas, while it was slightly lower at 13.02 litres in non-beneficiary villages. In the case of buffaloes, the peak yield reached 11.07 litres in beneficiary villages, whereas it was about 9 litres in non-beneficiary areas. The differences in peak milk yield for indigenous cows, crossbred cows, and buffaloes between the two types of villages were found to be statistically significant at $p<0.001$. The average of Average Daily Milk Yield (ADMY) of indigenous cows in beneficiary villages was around 6 litres, and in non-beneficiary villages, it was only 4.44 litres. In crossbred, the yield was 11.93 litres, and in non-beneficiary villages, it was about 10.20 litres, whereas buffaloes showed a yield of 8.46 litres in beneficiary villages, while the same was around 7.06 litres in non-beneficiary villages. Mann-Whitney U test showed a significant difference in ADMY of all three dairy animals of beneficiary and non-beneficiary farmers. It is clear from the data in Table 2 that the average Lactation Milk Yield (LMY) of indigenous cows in beneficiary villages was approximately 1480 liters, compared to about 1060 litres in non-beneficiary villages. For crossbred cows, the LMY was around 3500 litres in beneficiary areas, while it was roughly 2750 litres in non-beneficiary villages. In the case of buffaloes, the average yield was nearly 2290.37 litres in beneficiary

Table 2. Productive performance of dairy animals

Productive traits	NICRA beneficiary villages (n=60)	Non-beneficiary villages (n=60)	Mann-Whitney test		
			U statistics	Z value	P value
Peak yield (liters)					
Indigenous cow	7.82 ±0.11	6.52 ±0.11	474.000	-6.139	0.000
Crossbred	15.21 ±0.19	13.02 ±0.15	88.000	-8.555	0.000
Buffalo	11.07 ±0.13	9.27 ±0.17	270.000	-7.522	0.000
Average daily milk yield (liters)					
Indigenous cow	5.97 ±0.098	4.44 ±0.9	512.000	-5.889	0.000
Crossbred	11.93 ±0.16	10.20 ±0.14	50.000	-8.778	0.000
Buffalo	8.46 ±0.06	7.06 ±0.11	532.000	-5.993	0.000
Lactation milk yield (liters)					
Indigenous cow	1481.21 ±14.44	1059.96 ±12.70	222.000	-7.602	0.000
Crossbred	3504.19 ±46.60	2750.32 ±37.86	224.000	-9.048	0.000
Buffalo	2290.37 ±14.82	1827.90 ±25.77	231.000	-7.671	0.000
Lactation length (days)					
Indigenous cow	248.11 ±3.23	238.73 ±3.48	591.500	-5.298	0.000
Crossbred	293.73 ±1.43	269.64±1.80	239.500	-7.653	0.000
Buffalo	270.73 ±1.84	258.91 ±1.78	265.000	-7.498	0.000

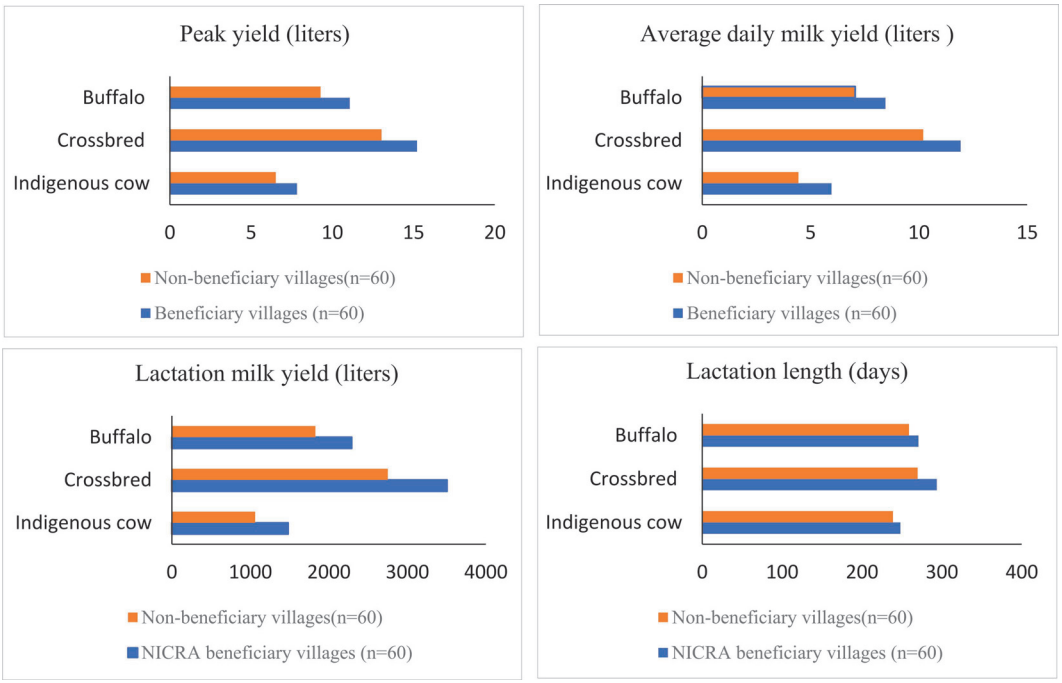

Figure 1. Productive performance of dairy animals in NICRA and non-NICRA villages

villages and 1827.90 litres in non-beneficiary ones. In case of the average lactation length of indigenous cows in beneficiary villages, it was approximately 248 days compared to around 238 days in non-beneficiary villages. For crossbred cows, the lactation period was about 293 days in beneficiary areas, whereas it was roughly 270 days in non-beneficiary villages. In the case of buffaloes, the lactation length averaged around 270 days in beneficiary villages and about 259 days in non-beneficiary ones. The difference was significant in the lactation lengths of dairy animals between the beneficiary and non-beneficiary villages.

Reproductive performance

A glance at Table 3 and Figure 2, which illustrates the age of dairy animals at first calving, shows that indigenous cows in beneficiary villages calved for the first time at an average age of 35.89 months, compared to 37.89 months in non-beneficiary villages. For crossbred cows, the average age at first calving was about 28 months in beneficiary villages and 30.36 months in non-beneficiary villages. In the case of buffaloes, the age at first calving was approximately 39.15 months in beneficiary villages, while it was 42.79 months in non-beneficiary ones. The difference in age at first calving relating the two groups was found to be statistically significant.

Table 3 also reveals that the average number of services per conception for indigenous cows, crossbred cows, and buffaloes in beneficiary villages was 1.19, 1.56, and 1.53, respectively. In contrast, the corresponding figures in non-beneficiary villages were significantly higher: 2.33 for indigenous cows, 3.05 for crossbred cows, and 2.30 for buffaloes. This indicates a significant difference in the number of services needed per conception between beneficiary and non-beneficiary villages. Regarding results for average calving interval presented in Table 3, in beneficiary villages, it was 388.88, 382.18 and 397.73 days for indigenous cows, crossbred and buffaloes, respectively. While in non-beneficiary

Table 3. Reproductive performance of dairy animals

Reproductive traits	NICRA beneficiary villages (n=60)	Non-beneficiary villages (n=60)	Mann-Whitney test		
			U statistics	Z value	P value
Age at first calving in months					
Indigenous cow	35.89 ±0.15	37.41 ±0.39	101.500	-8.450	0.000
Crossbred	28.25 ±0.09	30.36 ±0.28	5.000	-9.158	0.000
Buffalo	39.15 ±0.19	42.79 ±0.34	507.000	-6.186	0.000
Number of services per conception					
Indigenous cow	1.19 ±0.05)	2.33(±0.06)	185.000	-8.483	0.000
Crossbreed	1.56(±0.04)	3.05(±0.08)	406.500	-4.143	0.000
Buffalo	1.53(±0.07)	2.30(±0.10)	920.000	-3.568	0.000
Calving interval in days					
Indigenous cow	388.58(±3.57)	427.82(±1.65)	244.000	-7.514	0.000
Crossbreed	382.18(±2.03)	417.55(±1.74)	174.500	-8.044	0.000
Buffalo	397.73(±1.39)	432.64(±1.83)	422.000	-7.256	0.000

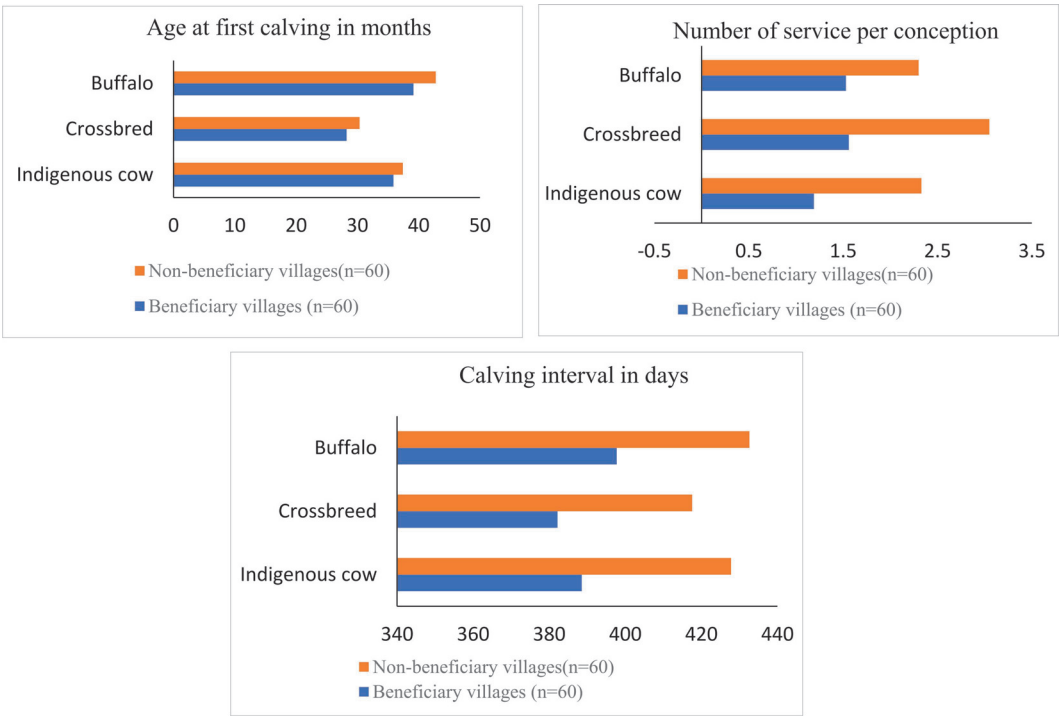

Figure 2. Reproductive performance of dairy animals in NICRA and non-NICRA villages

Table 4. Relation between performance of dairy animals and socio-economic variables

Association of socio-economic variables with performance parameters expressed in terms of correlation coefficient							
	Peak yield	Average daily milk yield	Lactation yield (litres)	Lactation length (days)	Age at first calving in months	No. of service per conception	Calving interval in days
Education	0.048	0.024	0.028	0.056	0.011	-0.020	-0.127
Experience	0.177	.184*	.200*	0.165	-0.271**	-0.190*	-0.201*
Family size	0.105	0.087	0.093	0.080	-0.116	-0.054	-0.034
Income(lacs)	0.062	0.062	0.053	0.077	-0.049	-0.056	-0.062
Family educational status	0.383**	0.372**	0.348**	0.284**	-0.375**	-0.393**	-0.259**
Operational landholding	0.027	0.006	0.015	0.034	-0.046	-0.063	0.004
Herd Size	0.046	0.115	0.109	0.045	-0.078	0.032	0.073
Extension contact of household	0.248**	0.286**	0.263**	0.200*	-0.234*	-0.222*	-0.136
Mass media/ social exposure of the household	0.237**	0.257**	0.237**	0.217*	-0.222*	-0.231*	-0.203*
Participation in extension activities	0.327**	0.335**	0.318**	0.267**	-0.280**	-0.307**	-0.243**

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed)

villages, for indigenous cows, crossbred and buffaloes, the intervals were 427.82, 417.55 and 432.64 days, respectively. Results showed that NICRA beneficiaries' dairy animals had a lower calving interval when compared to animals kept by non-beneficiaries. Hence, a significant difference was seen between beneficiary and non-beneficiary villages.

To understand the effect of socio-economic variables on the productive and reproductive performance of animals, a correlation analysis was done. Table 4 reveals that family educational status was strongly associated (significant at 0.01) with all the parameters of productive performance with positive outcomes and negatively correlated with the parameters like age at first calving, number of services per conception and calving interval in days. Experience was positively associated with average daily milk yield and lactation yield while negatively correlated with the age at first calving, number of services per conception and calving interval in days. extension contact, media exposure, and participation in extension activities all show strong positive associations with productive performance and negative associations with reproductive parameters.

DISCUSSION

In the productive performance indicators, indigenous cows, crossbred cows, and buffaloes of beneficiary farmers of NICRA had significantly higher performances than non-beneficiary farmers. The results of peak milk yield also support this finding, which is similar to the results of Meena et al., (2017) who reported that the peak yield in the villages where adoption took place was greater compared to the non-adopted villages. In case of average daily milk yield also, performance of dairy animals of beneficiary farmers were significantly higher than those of non-beneficiary farmers. The different interventions as part of NICRA could have contributed to helpe the beneficiaries to achieve a higher performance. It can be related with the results of Ponnusamy et al., (2019), where it has been recommended to provide a daily dose of 50 grams of mineral mixture for milch cows and buffaloes, and 20-25 grams per day for calves, which resulted in an average increase of 0.5 liters in daily milk production just after 15 days of supplementation. In a similar study by Gupta et al., (2017), it was observed that the daily average milk yield and total milk yield was significantly higher in the treatment group compared to the control group. The average total quantity of milk produced by an animal in its lactation period, was significantly higher among farmers of beneficiary than non-beneficiary farmers. A similar study by Chakravarty et al., (2021) found that using improved fodder crop varieties along with area-specific mineral mixture supplementation was highly effective in sustaining milk production during periods of heat stress. This result aligns with the findings reported by Madke et al., (2018), where the total milk yield in the treatment group was found to be higher than that of the control group. The results suggest that the adopted practices contributed positively to enhancing milk production, indicating their potential for wider adoption to improve dairy productivity. Same benefiting results were obtained in the case of lactation length also. The lactation lengths of buffaloes, crossbred cows, and indigenous cows were notably higher among beneficiaries of NICRA, than non-beneficiaries, which is on par with the results of Meena et al., (2015), in a study conducted in Uttar Pradesh.

To assess the reproductive performance, age at first calving, service per conception and calving interval were measured among dairy animal of farmers in beneficiary and non-beneficiary villages. The age at first calving was significantly higher in the dairy animals of beneficiary than non-beneficiary farmers, which is consistent with the results of Meena et al. (2017). Service per conception in beneficiary villages was significantly higher than in non- beneficiary. Similarly, NICRA beneficiaries' dairy animals had lower calving interval than non-beneficiaries' dairy animals. All these indicators pointed to the higher and improved reproductive performances among dairy animals of NICRA beneficiaries than those of non-beneficiaries. When key reproductive traits were recorded during the experimental period, Kumar et al., (2020) reported that the first postpartum estrus after calving, service period, and number of inseminations per conception were the effective technologies to enhance the reproductive performances. In short, both productive and reproductive parameters of dairy animals are better among beneficiary than non-beneficiary villages. A similar study demonstrated that supplementing the diet of crossbred cattle with an area-specific mineral mixture led to improved productive and

reproductive performance, particularly from the first postpartum estrus through to the final trimester (Muwel et al., 2020). Here, the results indicated the effectiveness of various technologies under NICRA to overcome different climate change barriers in dairy farming. NICRA project has proved to be crucial in providing positive outcomes, including increased incomes and adaptive capacities (Sodhi et al., 2023).

While analysing the socio-economic correlates, education has been found to be correlated with both productive and reproductive parameters significantly. The presence of educated persons in the family helps the family in better comprehension and use of the scientific publications and advisory services, and a better understanding and adoption of scientific advisory services leads to overall betterment in dairy production. Also, extension contacts, media exposure, and participation in extension activities showed similar results.

CONCLUSION

The impact of climatic change interventions on productive as well as reproductive performance of dairy animals in beneficiary villages as compared to non-beneficiary is significant. Field data and related studies suggest that feeding dairy animals a localised mineral combination improved their reproductive and productive capacities, which led to shorter service times, a delay in the onset of postpartum oestrus, and an increase in milk production. Therefore, supplementing dairy cows' diets with minerals may improve their reproductive health and boost their capacity to make milk. The findings of the study will guide to check further interventions' framing with satisfactory outcomes through proper channel at the right time with right amount. The correlation analysis indicates that socioeconomic factors, particularly education, experience, and extension participation, significantly enhance dairy animals' productive performance. These factors also help reduce reproductive inefficiencies by promoting the adoption of scientific practices. Strengthening awareness and outreach can thus play a vital role in improving dairy farming outcomes

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Research Article

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Evaluating the Effect of Extension Advisory Services (EAS) using Economic Index Score in Aspirational Districts

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HIGHLIGHTS

- EAS significantly enhanced economic outcomes, beneficiaries reporting higher EIS (Mean = 59.69) than non-beneficiaries (Mean = 50.84), confirmed by Welch's t-test and Bayesian inference (Cohen's d = 0.61).
- The district-wise disparities in Economic Index Score (EIS) highlighted uneven extension effectiveness.
- Socio-economic and extension-related factors such as farming experience, mass media exposure, social participation and extension contact were found to have significant positive correlations with EIS.
- Despite the overall positive impact, 23 per cent of farmers fell into the low-impact category, indicating the gaps in EAS outreach and inclusiveness.

ARTICLE INFO

Keywords: Economic Index Score (EIS), Extension Advisory Services (EAS), Aspirational Districts, Rural livelihoods and Economic well-being.

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ABSTRACT

The Aspirational Districts Programme (ADP) aims to uplift India's most developmentally lagging regions through targeted interventions across health, education, agriculture, and infrastructure. The study evaluated the economic impact of EAS on farmers in four aspirational districts of Bihar and Jharkhand using a novel Economic Index Score (EIS) during 2024-25. The EIS was constructed using five key dimensions viz., employment generation, asset creation, agricultural productivity, cost reduction, and value addition, capturing both the presence and duration of economic benefits from EAS. The data were collected from 320 farmers and 30 service providers personally. The statistical analysis, including Welch's ANOVA, Games-Howell post hoc tests, and Bayesian inference, revealed significant differences in EIS between beneficiary and non-beneficiary farmers, with a moderate to large effect size (Cohen's d = 0.61). The district-wise comparisons also highlighted disparities, with Muzaffarpur showing the highest economic gains and Hazaribagh the lowest. The correlation analysis identified experience, mass media exposure, social participation, and extension contact as significant predictors of EIS. The findings established that EAS plays a crucial role in enhancing rural livelihoods, yet variations across districts and farmer profiles underscore the need for context-specific, inclusive extension models.

INTRODUCTION

Agriculture continues to be the mainstay of the Indian rural economy, employing over 54.6 per cent of the total workforce and contributing significantly to national food security (Ministry of Agriculture & Farmers Welfare, 2023). Despite rapid economic growth in some sectors, a large proportion of India's rural population remains economically vulnerable, particularly in backward and underdeveloped

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regions. These disparities are most pronounced in the Aspirational Districts, identified by the NITI Aayog in 2018 as part of the Aspirational Districts Programme. The program targets 112 districts across the country that lag in key socio-economic indicators, including health, education, agriculture, financial inclusion, and basic infrastructure (NITI Aayog, 2022). In many of these districts, concentrated in states like Bihar, Jharkhand, Uttar Pradesh, Chhattisgarh, and Odisha, agriculture is often characterized by low productivity, fragmented landholdings, inadequate irrigation and limited access to extension and market services. Farmers in these regions are highly dependent on monsoon rainfall, suffer from irregular income, and have poor access to institutional credit and technological innovations (World Bank, 2021). Moreover, the persistence of poverty and lack of diversification in income sources further increases the economic vulnerability of rural households (Chand et al., 2017). While various national-level schemes aim to enhance farmer welfare, such as PM-KISAN, Soil Health Card, Kisan Credit Card, and Pradhan Mantri Fasal Bima Yojana, their effectiveness often varies based on the socio-economic status of the beneficiaries. Most studies examining rural livelihoods rely on discrete variables like income, landholding, or education levels in isolation. However, there is a critical need for a composite and systematic framework to quantify and understand the economic realities of farmers, especially in these development-deficient districts. In response to this gap, the present study developed an Economic Index Score, a composite measure to assess the effect of extension advisory interventions. This decision was grounded in the understanding that while income is a critical indicator, it alone does not capture the multifaceted nature of economic status, particularly in rural and developing contexts. The income can be highly variable, seasonal, and often inaccurately reported, making it an unreliable sole indicator for understanding household economic conditions (Deaton, 1997; Filmer & Pritchett, 2001). The dimensions were chosen to collectively represent the core pathways through which extension advisory services interventions translate into tangible economic gains for rural households. Understanding rural livelihoods through this economic lens is essential not only for targeted policy formulation but also for prioritizing interventions under the Aspirational Districts Programme.

Looking ahead, the use of composite indices can be extended to longitudinal monitoring of livelihood changes over time, assessment of program impact and identification of region-specific development bottlenecks. The findings of this study are also expected to contribute to the broader policy discourse on doubling farmers' income, building rural resilience and reducing regional disparities as envisioned under the National Policy for Farmers and SDG Goal 1 & 2 viz., no poverty and zero hunger respectively (Bhavani, 2023).

METHODOLOGY

The study was conducted in Bihar and Jharkhand, selected purposively from India's eastern region due to their high number of aspirational districts and socio-economic relevance. A multi-stage sampling technique was adopted. Two aspirational districts were randomly selected from each state namely, Hazaribagh & Lohardaga in Jharkhand and Muzaffarpur & Gaya in Bihar. From each district, two blocks and subsequently two villages per block were randomly selected, totalling 16 villages. From each village, 20 farmers were randomly selected, giving a total of 320 farmer respondents. Additionally, 30 service professionals were purposively selected, making the total sample size 350. Economic Index Score (EIS) was employed as a composite measure to assess the economic well-being of rural households in aspirational districts. Recognizing the limitations of income as a sole indicator, owing to its variability and inaccuracy in rural settings, a multidimensional approach was adopted. The EIS incorporates five key dimensions of economic benefit that reflect the tangible impact of extension advisory services interventions namely, employment generation, asset creation, agricultural productivity, cost reduction and value addition. To quantify perceived economic impact, a standardized five-point ordinal scale was used, based on the duration of benefit. The respondents scored each dimension from 0 (no benefit) to 4 (benefit for more than 5 years). This method captures both the presence and longevity of economic gains, offering a detailed representation of perceived impact from the extension advisory services. The maximum possible score per respondent was 20 (5 indicators × 4) and the minimum was 0. The EIS was calculated using the formula:

$$EIS = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100$$

This yielded a standardized score between 0 and 100 for each respondent, representing the extent of perceived economic wellbeing. The respondents were subsequently categorized into low, moderate and high economic impact groups using the cumulative square root frequency method for further comparative analysis. The Games-Howell post hoc test was used for pairwise comparisons due to unequal variances across the districts. A Welch's *t*-test was conducted to examine significant differences in the EIS between farmers who were beneficiaries of Extension Advisory Services and those who were not. The Cohen's d test was used to quantify the effect size between two groups, measuring the magnitude of the difference between their means. For the purpose of evaluating the effect of EAS, farmers were classified into two groups based on their major source of advisory services. Farmers were assigned to the beneficiary group (treatment) if over 60 per cent of their farming decisions were influenced by formal channels such as KVKs, ATMA, SAUs or ICT-based platforms. Conversely, those relying primarily on informal sources like peer networks or input dealers were classified as non-beneficiaries (control group). Based on the review of literature and theoretical framework, the following hypotheses were formulated to guide the analysis.

It was hypothesised that there is no significant difference in the EIS between beneficiary and non-beneficiary farmers EAS (H_o). whereas as an alternate there is a significant difference in the EIS between beneficiary and non-beneficiary farmers of EAS (H_1):

$$H_o : \mu_1 = \mu_2,\ H_1: \mu_1 \neq \mu_2$$

RESULTS

Categorization and distribution of farmers based on their economic index score

Table 1 presents the categorization of farmers based on their EIS using cumulative square root frequency into three groups,

namely low, moderate, and high impact. The analysis of EIS across four aspirational districts viz., Gaya, Hazaribagh, Lohardaga, and Muzaffarpur, revealed significant differences in perceived economic benefits derived from extension advisory services. Using Welch's ANOVA (Table 2), which accounts for unequal variances, a statistically significant difference was observed among the districts, F (3,175.4) = 7.71, p = 0.0000724 with a partial eta squared (η^2_ρ) value of 0.12, indicating a moderate effect size. As represented in Figure 1, the mean EIS was highest in Muzaffarpur, followed by Gaya, Lohardaga and lowest in Hazaribagh. Table 3 presents the pairwise Games-Howell post hoc test, which confirmed that these differences were statistically significant, particularly between Muzaffarpur and Hazaribagh. A Welch's *t*-test was conducted to examine whether there is a significant difference in the Economic Impact Score (EIS) between farmers who were beneficiaries of Extension Advisory Services and those who were not (Table 4) and the results revealed a statistically significant difference in mean EIS between the two groups: ($t_{\text{Welch}(318)} = 5.43$, $p = 1.10 \times 10^{-7}$). The mean EIS for beneficiaries was significantly higher than that of non-beneficiaries as presented in Figure 2. The effect size, measured by Cohen's $d = 0.61$, suggested a moderate to large effect, indicating practical significance. Alzahrani et al., (2023) assessed the efficacy of public extension services and found similar results. The 95 per cent confidence interval for the difference in means [5.49, 11.79] further confirmed the robustness of this result.

Table 1. Categorization and distribution of farmers based on their economic index score

Category	Range	Frequency	Percentage
Low Impact	<42.29	74	23.125
Moderate Impact	42.29-71.44	198	61.875
High Impact	>71.44	48	15
Total	320	100	

Table 2. Test Summary of district-wise comparison of EIS

Component	Details
Test Used	Welch's ANOVA
Test Statistic	F (3, 175.4) = 7.71
p-value	7.24×10^{-5}
Effect Size	Partial Eta Squared (η^2_ρ) = 0.12

Table 3. Games-Howell Post-hoc Test – Pairwise District Comparison of EIS

District Pair	Mean Difference	p-value (adjusted)
Muzaffarpur vs Hazaribagh	10.81	p < 0.001 (Significant)
Muzaffarpur vs Lohardaga	6.87	p < 0.05 (Significant)
Muzaffarpur vs Gaya	3.74	Not Significant
Gaya vs Hazaribagh	7.07	p < 0.05 (Significant)
Gaya vs Lohardaga	3.13	Not Significant
Lohardaga vs Hazaribagh	3.94	Not Significant

Table 4. Welch's t-test comparison of EIS between beneficiary and non-beneficiary groups

Test Parameter	Value
Test Used	Welch's t-test
Test Statistic	$t_{(318)} = 5.43$
p-value	1.10×10^{-7}
Effect Size	Cohen's $d = 0.61$ *(moderate)*
Sample Size	$n = 320$

Testing hypothesis

The log Bayes Factor value of $\log_{10}(B_{01})$ = -11.55 strongly supports the alternative hypothesis (H_1). A negative log Bayes Factor (especially below -2 or -3) indicates increasing evidence against the null hypothesis. In this case, Bayes Factor value is considered very strong evidence in favour of a real difference between the groups of beneficiaries to the non-beneficiaries. Since

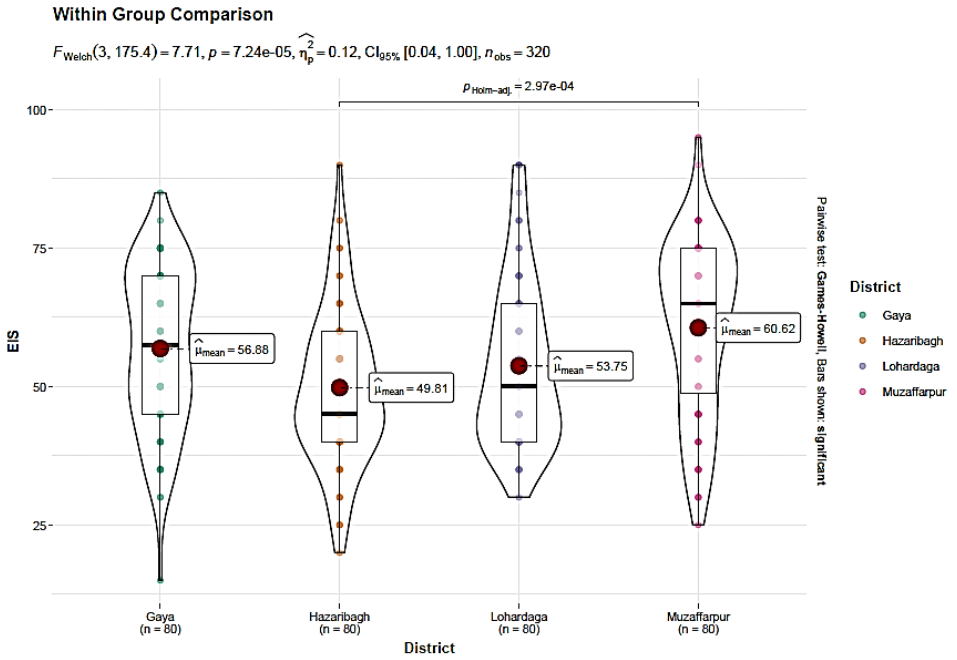

Figure 1. Violin plot representation of EIS among the respondents across the districts

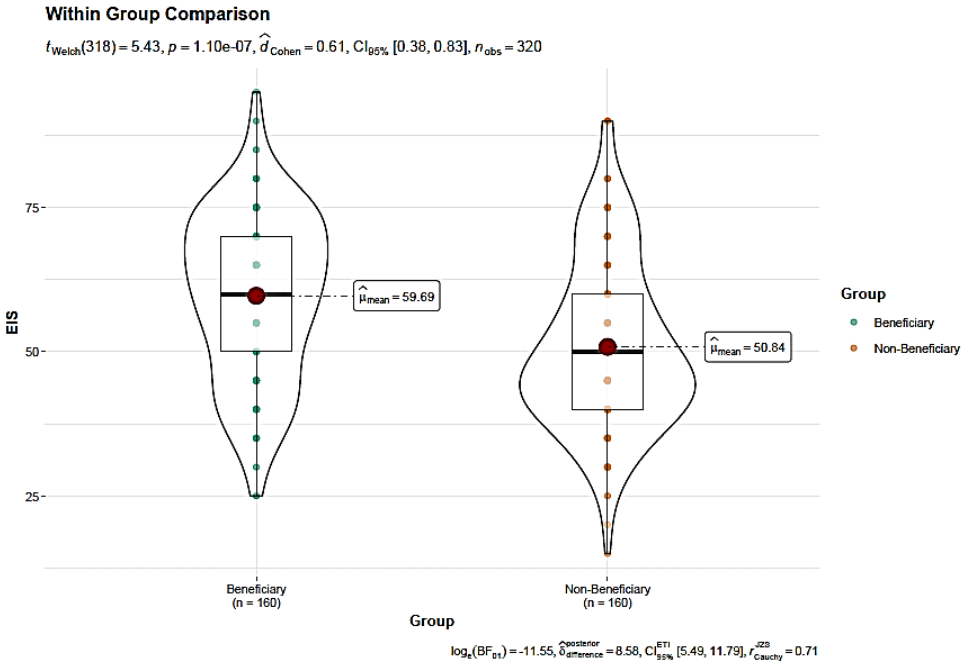

Figure 2. Violin plot representation of EIS of beneficiaries and non-beneficiaries

Table 5. Influence of Farmer Attributes and Extension Factors on EIS

Variable	Correlation with EIS	p-value (Sig.)	Interpretation
Mass Media Exposure	0.348	0.000**	Moderate positive relationship with EIS, even after controlling for other variables.
Age	0.043	0.443	No significant relationship with EIS.
Experience	0.407	0.000**	Strongest predictor among all; experience significantly influences EIS.
StandardAnimal Unit	0.143	0.011*	Weak positive but significant effect.
Social Participation	0.288	0.000**	Moderate positive effect on EIS.
Extension Contact	0.348	0.000**	Also has a moderate and significant positive impact.

*Significant at 5% LOS, **Significant at 1 % LOS

the mean EIS for beneficiaries (μ = 59.69) is higher than that of non-beneficiaries (μ = 50.84), we can confidently conclude that receiving extension advisory services had a positive and significant economic impact on farmers. These results are in line with Singh et al., (2015) & Wossen et al., (2017).

Influence of farmer attributes and extension factors on EIS

As represented in Table 5, the correlation between various farmer attributes and EIS concluded that experience, extension contact, and mass media exposure had significant and moderate to strong positive influence on EIS, while age shows no significant relationship. The standard animal unit and social participation also contribute positively, though to a lesser extent. These findings are in line with Priscilla et al., (2021).

DISCUSSION

The analysis of EIS revealed significant variations in the effectiveness of Extension Advisory Services across aspirational districts in Bihar and Jharkhand. As supported by the findings of Jaiswal et al., (2018), the majority of respondents fall under the moderate impact category, which suggested that while EAS contributes positively to farmers' economic wellbeing, the benefits remain uneven and often limited in scale. Only 15 per cent of farmers reported high impact, pointing to the presence of enabling factors such as strong extension-farmer linkages, better information access or higher social participation that are not uniformly available. Tayang et al., (2024) also confirmed the positive impact of EAS on rural livelihoods. Kumar et al., (2022) observed the economic impact of the *Meghdoot* agro-advisory application in terms of the yield performance of barley and wheat in the case of registered and non-registered farmers. Using a quantitative approach, they highlighted that access to advisory services directly correlates with improved income levels, when services are tailored to local conditions and farmers' specific needs. The mean EIS differs significantly among the four districts. Muzaffarpur was showing the highest economic gains, followed by Gaya, Lohardaga and Hazaribagh. This trend implies that local contextual factors such as institutional efficiency, service delivery models and infrastructure play a critical role in shaping EAS outcomes and reflect the differences in the effectiveness and accessibility of extension advisory services. These findings align with Chand et al., (2015), who argue that districts with better ICT use, proactive extension mechanisms and stakeholder linkages report higher service effectiveness. Conversely, the low performance of Hazaribagh supports Nagar et al., (2021), who attributed regional disparities to poor targeting, limited field outreach, poor relevance of advice,

lack of follow-up and institutional trust deficits. A statistically significant difference in EIS is also observed between beneficiary and non-beneficiary farmers. The beneficiaries report a higher mean compared to non-beneficiaries, with a moderate effect size, indicating that EAS contributes meaningfully to economic wellbeing. Similar results were found by Venu et al., (2013), who evaluated ATMA's effectiveness in two Indian districts, Ahmednagar (Maharashtra) and Dahod (Gujarat) by comparing outcomes for ATMA and non-ATMA farmers. The results showed a significant increase in crop yields, returns and farm income in Ahmednagar. This difference is further substantiated by Bayesian inference, which provides decisive evidence in favour of a real difference between the groups. These results corroborate earlier findings by Davis et al., (2018) who emphasize that timely, context-specific extension information improves farm decision-making, productivity and income. The observed district-wise variation suggests that location explains part of the impact, but individual-level socio-economic factors such as education, landholding size, group membership and frequency of extension contact are also influential. This supports Singh et al., (2023), who highlighted the multifactorial nature of EAS outcomes. Education and land holding size were observed linked with the adoption of weather-based agro-advisories by Kumar et al., (2021). Interestingly, a substantial minority falls into the low impact group, suggesting systemic exclusions possibly due to poor awareness, marginalization, or service inadequacy. These outliers indicate a critical gap that calls for targeted interventions, especially in underserved areas and among vulnerable groups. While the findings generally align with prior research, they also highlight persistent inequities in extension reach and impact. The positive outcomes among beneficiaries emphasize the potential of EAS, yet the underperformance in certain districts and among non-beneficiaries indicates structural and delivery-related weaknesses. The variation also underscores the importance of contextually adaptive, location-specific extension models. Adhiguru et al., (2009), highlighted how regional disparities in infrastructure and extension personnel availability could cause differential access and utilisation levels. Similarly, Yaseen et al., (2021); Sentibenla & Jha (2024) also noted that location-specific factors often determine the success or failure of extension interventions.

Overall, the study established a clear relationship between access to EAS and economic wellbeing among farmers. It founded a consistent trend of higher EIS among beneficiaries and in districts with stronger institutional setups. However, exceptions in the form of low-impact respondents and inter-district disparities signal the need for inclusive and differentiated extension strategies. The strengthening EAS through improved targeting, regular follow-ups and participatory approaches can ensure broader and more equitable impacts, particularly in the developmentally lagging aspirational districts.

CONCLUSION

This study established that access to quality extension services leads to significant improvements in the economic well-being of farmers in underdeveloped regions. The evidence confirmed that farmers receiving advisory support showed higher gains in employment, productivity, asset creation, cost efficiency and value addition than those without such access. The developed economic assessment tool effectively captures these outcomes and reveals important variations across districts and farmer profiles. These findings underscore that timely, inclusive and context-specific extension services are essential for achieving equitable rural development. The results validate the core hypothesis that targeted extension interventions positively influence economic outcomes and support the broader goals of agricultural transformation and regional equity.

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Research Article

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Adoption of Climate-Smart Agriculture (CSA) in Flood-Affected Regions of Darbhanga

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HIGHLIGHTS

- Knowledge and income strongly predict CSA adoption; informed, economically secure farmers adopt more climate-resilient practices.
- CSA adoption was uneven; crop production sees higher uptake than smart water and energy interventions.
- Regression explains 50 per cent adoption variance; education, family size, and extension contact significantly influence adoption in flood-prone areas.

ARTICLE INFO

Keywords: CSA adoption, Flood-prone, Climate-smart practices, Regression, Bihar.

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Conflict of Interest: None

Research ethics statement(s):
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ABSTRACT

The study aimed to evaluate the extent of adoption of Climate Smart Agriculture (CSA) practices among farmers residing in flood-prone areas of Darbhanga, Bihar, and to identify the key socio-economic factors influencing adoption. Data were collected during 2024–2025 from 160 respondents randomly selected from sixteen villages across four flood-affected blocks. A pre-tested interview schedule encompassing five CSA components was employed to gather information on adoption levels and socio-economic characteristics. The adoption of CSA practices was predominantly partial and practice-specific. Crop production practices recorded mean adoption rate of 49.51 per cent, whereas smart water management at 38.37 per cent. Overall, 64.16 per cent of the respondents exhibited a moderate adoption level. Correlation analysis demonstrated significant positive associations between adoption and variables such as knowledge, income, education, and family size. Further, the regression model ($R^2 = 0.500$; $F = 13.451$; $p < 0.01$) identified knowledge, income, education, family size, and extension contact as significant predictors of CSA adoption. The study concluded that improving farmers' knowledge and enhancing their economic capacity could substantially increase CSA adoption, thereby strengthening climate resilience. These results underscore the importance of targeted extension services and capacity-building programs tailored to vulnerable regions.

INTRODUCTION

India's agriculture is mostly rain-fed and extremely vulnerable to natural disasters like droughts and floods, especially in eastern states like Bihar. Flooding regularly affects the Darbhanga district in northern Bihar, upsetting farming practices, livelihoods, and food security. The implementation of Climate Smart Agriculture (CSA) techniques is essential in these delicate agro-ecological zones (Shitu et al., (2018). According to the Food and Agriculture Organization (FAO), CSA aims to accomplish national food security and development objectives while also improving resilience (adaptation), lowering greenhouse gas emissions (mitigation), and sustainably increasing productivity. Stress-tolerant crop varieties, resource-conserving technologies, enhanced water harvesting, integrated nutrient management, and early warning systems are some of the practices covered by CSA.

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India is the nation most affected by flooding after Bangladesh. One-eighth of the country's land area, or about 40 million hectares, is vulnerable to flooding. On average, 14,52,904 homes are damaged, 1793 people are killed, 85,599 cattle are killed, and 7.35 million hectares of land are impacted annually. Floods cause an average of 575 million US dollars in total losses (Dutta & Watts, 2010). Of India's 104.1 million inhabitants, 88.7 per cent live in rural areas, making Bihar the state most vulnerable to flooding. 79.11 million people, or nearly 76 per cent of the population, live in Bihar where flooding is a constant threat. According to WRD (2015), more than 73 per cent of Bihar's land area is designated as a flood-affected region. The main cause of floods in north Bihar is the high water flow brought about by the Himalayan river ranges, which include the Kosi, Gandak, Burhi Gandak, Bagmati, Kamla Balan, Mahananda, and Adhwara. These rivers originate in Nepal. North Bihar invariably floods as a result of these rivers' high discharge and heavy sediment load during the rainy season. Saharsa, Khagaria, Gopalganj, Katihar, Darbhanga, Madhubani, Supaul, East Champaran, West Champaran, Begusarai, and other districts that are within the catchment area of these rivers are the districts in Bihar that have been most severely affected by flooding. North Bihar has experienced the most floods over the past 30 years, and the overall area impacted by floods in Bihar has increased. One of the districts in North Bihar that is particularly impacted by the yearly flood is Darbhanga. Over 90 per cent of the 3.93 million people who live in the Darbhanga district reside in rural areas (DHSD, 2012). The Himalayan river range causes the most flooding in the district in Biraul, Kusheshwar Asthan (East and West), Ghanshayampur, Singhwara, Keoti, and Jale. Usually lasting three to five months at a time, the flooding has a significant negative impact on human life and living conditions, particularly in the marginalized communities.

In Bihar, the National Innovations on Climate Resilient Agriculture (NICRA) program has been instrumental in promoting CSA practices. However, the extent of adoption and the factors influencing it, particularly in flood-prone areas like Darbhanga, require further investigation. Understanding these determinants is essential for designing effective interventions and policies that enhance the resilience of farming communities (Maya et al., 2025; Koyu et al., 2021). Despite policy initiatives and pilot programs promoting CSA, actual adoption among smallholder farmers in vulnerable regions remains limited and uneven. The purpose of this paper is to highlight the various factors influencing the adoption of CSA practices, including socio-economic variables, access to information, and institutional support. For instance, research in the Bundelkhand region highlighted that variables such as education level, income, farm size, access to extension services, and awareness significantly influence the likelihood of adopting climate-resilient technologies.

METHODOLOGY

The state of Bihar is composed of 38 districts, of which Darbhanga was purposively selected for the present study due to its frequent exposure to seasonal flooding and its prominence in flood-prone agro-ecological zones. According to the Bihar State Disaster Management Authority (2022), Darbhanga is one of the top five districts in the state in terms of flood frequency and agricultural damage caused by climate-induced disasters. For investigation during 2024-25, Hanuman Nagar, Singhwara, Jale and Kusheshwar Asthan blocks of Darbhanga district were selected purposively based on their history of flood vulnerability, agricultural activity, and accessibility. From each block, four villages with notable agricultural activity and prior exposure to Climate Smart Agriculture (CSA) initiatives under NICRA or Krishi Vigyan Kendra (KVK) were purposively chosen, resulting in a total of sixteen villages. A complete household listing of all farming families in each selected village was conducted. From this list, a total of 160 respondents were randomly selected using proportionate random sampling. Primary data were collected through a pre-tested and structured interview schedule administered via personal interviews. The schedule was designed to collect information on socio-economic characteristics, awareness, and adoption of various CSA practices. It consisted of items related to major CSA interventions such as the use of stress-tolerant seeds, raised bed planting, organic inputs, integrated pest management, and water harvesting techniques. Respondents were asked to indicate their level of adoption for each practice using a 3-point Likert scale: fully adopted (2), partially adopted (1), and not adopted (0). The maximum attainable adoption score across all practices was 25.

An adoption Index was calculated for each respondent using the formula:

$$\text{Adoption index} = \frac{\text{Total score achieved}}{\text{Total achievable score}} \times 100$$

To assess the determinants of CSA adoption, data were analysed using multiple linear regression analysis. The dependent variable was the total adoption score of CSA practices. Independent variables included both socio-economic and psychological factors. Statistical analysis was carried out using SPSS 27.0 software. The strength and direction of influence of each predictor variable were examined through regression coefficients and significance values ($p < 0.05$). Multicollinearity diagnostics and model fit statistics such as R^2 and Adjusted R^2 were also evaluated to ensure robustness of the model.

RESULTS

Table 1 presents the weighted mean adoption scores for these CSA components among farmers affected by floods in Darbhanga. Crop production practices had the highest mean adoption rate of 49.51 per cent, largely due to the extensive use of flood-tolerant varieties and intercropping methods (Figure 1). Soil fertility management followed with a mean adoption of 42.33 per cent, reflecting widespread legume rotation practices in the area. Weather-smart and energy-smart practices showed moderate adoption rates of 40.20 per cent and 39.37 per cent, respectively, demonstrating some use of crop insurance and minimum-tillage, although uptake of forecasting tools and renewable energy remained limited. Smart water management recorded the lowest adoption score at 38.37 per cent, indicating ongoing difficulties in adopting technologies like fertigation and water harvesting systems.

The relationship between selected socio-personal, economic, and psychological characteristics of respondents and their adoption

Table 1. Specific Climate-Smart Agriculture (CSA) practices in Flood-affected regions

CSA Component	Mean Adoption (%)	Rank
Crop Production Practices	49.51	1
Soil Fertility Management	42.33	2
Weather-Smart Practices	40.20	3
Energy-Smart Practices	39.37	4
Smart Water Management	38.37	5

(Scores based on 2 = fully adopted, 1 = partially adopted, 0 = not adopted, averaged across practices)

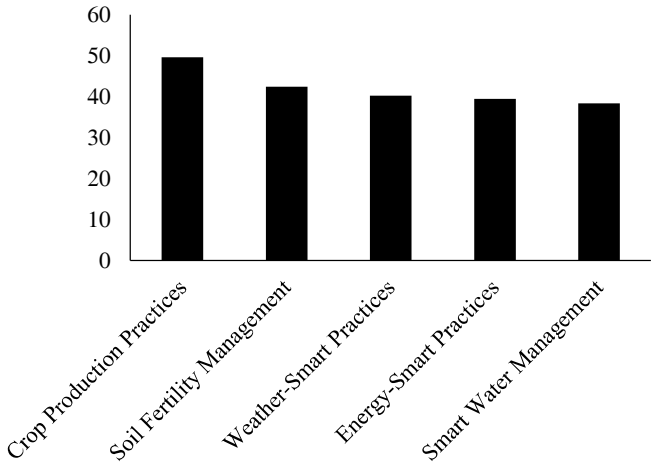

Figure 1. Weighted Mean Adoption Scores of Climate-Smart Agriculture

level of Climate Smart Agriculture (CSA) technologies was examined using Pearson's correlation analysis. The results, presented in Table 2, showed that knowledge of CSA practices was the most significant factor positively correlated with adoption ($r = 0.558$, $p < 0.01$), indicating that farmers with greater knowledge were more likely to adopt CSA practices. Income also demonstrated a significant positive correlation ($r = 0.322$, $p < 0.01$), suggesting that economically better-off farmers possessed greater capacity and willingness to invest in CSA interventions, likely due to enhanced access to resources and inputs. Education exhibited a moderate positive correlation ($r = 0.174$, $p < 0.05$), implying that more educated farmers were more receptive to adopting climate-resilient innovations. Family size also showed a positive and significant correlation ($r = 0.194$, $p < 0.05$), reflecting increased labour availability within larger households, which facilitated better management and implementation of CSA practices. Other variables, including age ($r = -0.002$), marital status ($r = -0.055$), landholding size ($r = 0.120$), extension contact ($r = 0.129$), scientific orientation ($r = -0.051$), attitude ($r = 0.015$), and family type ($r = 0.124$), did not exhibit statistically significant associations with adoption levels. Although extension contact and landholding showed weak positive trends, these were not significant at the 5% level, indicating that additional mediating factors might affect their influence on adoption. These findings highlighted knowledge and economic capacity as primary drivers of CSA adoption among smallholder farmers in flood-prone areas, while education and family labour availability provided supportive roles. The results also suggested that institutional support mechanisms, such as extension services and training, require further strengthening to exert a statistically meaningful impact on adoption behaviour.

Table 3 showed that the regression model was statistically significant ($F = 13.451$; $p \leq 0.01$) with a coefficient of determination (R^2) of 0.500, indicating that approximately 50% of the variation in CSA adoption among farmers was explained by the eleven independent variables included in the model. Among the predictors, knowledge emerged as the most influential variable, with a highly significant positive coefficient ($B = 0.503$, $t = 9.623$, $p \leq 0.01$), suggesting that farmers with higher levels of knowledge were more likely to adopt CSA practices. This result aligned with the correlation analysis and underscored the importance of information and awareness in adoption behaviour. Income also exhibited a significant positive effect ($B = 0.101$, $t = 4.051$, $p \leq 0.01$), indicating that farmers with higher income levels tended to invest more in CSA technologies. Similarly, family size ($B = 0.303$, $t = 3.236$, $p \leq 0.01$) showed a positive association with adoption, implying that larger households had greater labour availability and capacity to implement multiple CSA practices. Other variables significant at the 5% level included education ($B = 0.387$, $t = 1.355$, $p \leq 0.05$) and extension contact ($B = 0.072$, $t = 1.509$, $p \leq 0.05$), suggesting

Table 2. Association of profile characteristics of respondents and adoption of CSA technologies in flood-prone area

Variables (Unit)	Adoption value of 'r'
Age	-0.002
Marital	-0.055
Family type	0.124
Family size	0.194*
Education	0.174*
Landholding	0.120
Income	0.322**
Extension contact	0.129
Scientific Orientation	-0.051
Attitude	0.015
Knowledge	0.558**

* - Significant at 5 % level of probability, ** - Significant at 1 % level of probability

Table 3. Multiple regression analysis of selected independent variables with the level of adoption

Variable	Unstandardized Coefficient (B)	Standard Error (S.E.)	t-value
Age	-0.089	0.044	-2.033**
Marital	0.331	1.031	0.321
Family type	-0.277	0.671	-0.413
Family size	0.303	0.094	3.236**
Education	0.387	0.286	1.355*
Landholding	0.019	0.2	0.095
Income	0.101	0.10	4.051**
Extension contact	0.072	0.048	1.509*
Scientific Orientation	0.149	0.159	0.935
Attitude	-0.045	0.062	-0.721
Knowledge	0.503	0.052	9.623**

Significant pd" 0.01 level of probability $R^2 = 0.500$, F value= 13.451; *Significant pd" 0.05 level of probability

that farmers with more formal education and frequent interactions with extension personnel were more inclined to adopt CSA interventions. In contrast, age ($B = -0.089$, $t = -2.033$, $p \leq 0.01$) showed a significant negative relationship, indicating that younger farmers were more receptive to innovative agricultural practices than older ones. Marital status, family type, landholding, scientific orientation, and attitude did not demonstrate statistically significant effects in the model, indicating limited predictive power in this context. These findings highlighted knowledge, income, family size, education, and extension contact as critical determinants of CSA adoption, emphasizing the need for integrated extension programs that combine technical training with economic support mechanisms.

DISCUSSION

The present study revealed that the adoption of Climate Smart Agriculture (CSA) practices among farmers in flood-prone areas of Darbhanga was largely partial and practice-specific. Among the five CSA components assessed, crop production practices registered the highest adoption rate (49.51%), driven mainly by the use of flood-tolerant varieties and intercropping systems. This finding aligns with Kapoor & Pal (2024), who reported that low-cost, resource-efficient practices tend to gain wider acceptance among farmers compared to more capital-intensive technologies such as drip irrigation or fertigation. The prominence of legume rotations within soil fertility management further reflects farmers' recognition of natural nitrogen fixation benefits and soil health improvement.

Correlation analysis identified knowledge and income as the most significant factors positively associated with CSA adoption, supporting Singh (2020); Thakur et al., (2024) concluded that awareness and economic capacity critically influence technology uptake. Education and family size also demonstrated positive correlations, suggesting that better-educated farmers with larger household labour pools are more likely to implement diverse CSA practices. Extension contact showed a positive but statistically insignificant bivariate association; nonetheless, its role in enhancing adoption was corroborated by prior studies (Lakshmi et al., 2023; Kumar et al., 2025; Sonu & Jha, 2025), which emphasise that frequent interactions with extension personnel foster farmer confidence and awareness.

Knowledge emerged as the strongest predictor in the regression analysis, underscoring the pivotal role of information dissemination in facilitating CSA adoption. Consistent with recent literature (Erekalo & Yadda, 2023; Kirungi et al., 2023; Petros et al., 2024), the study found that access to climate-related information and education significantly shapes farmers' decisions to adopt climate-resilient practices. The absence of a clear directional effect of age on adoption, as also noted by Petros et al., (2024), suggests that factors influencing adoption are multifaceted, transcending simple demographic characteristics.

Furthermore, the study highlighted that socio-economic factors and institutional support mechanisms often outweigh physical resource endowments like landholding size in influencing CSA adoption. This observation aligns with Khoza et al., (2020); Jatav et al., (2023); Shitu & Nain (2024) who stress the importance of gender-sensitive and socio-psychological considerations in designing CSA interventions. Such nuanced understanding is crucial for developing policies that address the heterogeneity of farmer needs and capacities. These findings collectively emphasize the urgent need for targeted, knowledge-driven extension strategies that combine technical training with economic support to enhance CSA adoption in flood-vulnerable regions like Darbhanga. Extension programs should prioritize high-impact, low-cost CSA practices, supported by demonstration plots and farmer field schools to effectively bridge the adoption gap. Additionally, institutional mechanisms offering input subsidies and facilitating peer-to-peer learning can reinforce farmers' adaptive capacities, ultimately contributing to long-term agricultural resilience.

CONCLUSION

The adoption of CSA was found to be strongly predicted by knowledge and income, suggesting that farmers who are more financially secure and knowledgeable are more likely to adopt climate-resilient practices. Crop production techniques were more widely adopted than smart water and energy interventions, indicating an uneven adoption pattern. To encourage farmers to increase adoption rates, these findings highlight the significance of expanding farmers' access to CSA knowledge through targeted extension services, field demonstrations, and training initiatives. Additionally, strengthening institutional support, providing input subsidies, and promoting farmer-to-farmer knowledge sharing are crucial strategies to expand CSA adoption. Policy measures tailored to economically vulnerable and climate-sensitive regions like North Bihar will play a vital role in fostering sustainable agricultural resilience and ensuring long-term livelihood security.

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Research Article

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The Role of Cognitive Style in Academic Achievements and Creative Thinking among Students

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HIGHLIGHTS

- Examines cognitive styles influencing decision-making: systematic (analytical) and intuitive (holistic, rapid).
- Compares the impacts of both styles on problem-solving and learning approaches.
- Highlights individual differences and their implications in education and organizational behaviour.
- Recommends tailoring strategies to cognitive preferences for improved performance and engagement.

ARTICLE INFO

Keywords: Cognitive style, Academic achievement, Creative thinking, College students, Tripura.

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ABSTRACT

Cognitive ability significantly influences an individual's life trajectory. The study explored the cognitive styles of undergraduate students in the Sadar sub-division of West Tripura district, Tripura, during 2024-25. A stratified random sample of 100 students was selected for the investigation. The study addressed specific research objectives and hypotheses related to gender based variations in cognitive style and its connection with academic achievement and creative thinking. Comparison of academic achievement scores between students with systematic and intuitive cognitive styles yielded a significant difference ($t = 2.51$, $p < 0.05$), favouring those with a systematic style. Pearson correlation analysis revealed strong positive and significant relationships between academic performance and both systematic ($r = 0.86$, $tr = 16.68$) and intuitive ($r = 0.70$, $tr = 13.57$) cognitive styles. In particular, students with a systematic cognitive style tended to perform better academically than those with an intuitive style. Further, students with a systematic cognitive style consistently secured higher academic scores compared to their intuitive counterparts. The findings contribute to the broader understanding of cognitive styles in educational settings and provide insights for enhancing academic support strategies in higher education.

INTRODUCTION

In everyday life, every individual has to engage in interactions with their environment to continue the battle of life. Driven by the demands of life and livelihood, people are constantly immersed in thoughts. Every puzzle of life has to be solved by human cognitive abilities. Thus, cognitive processes continually occur within individuals. Essentially, cognitive processes are cerebrum mechanisms that determine the acquisition of knowledge and the level of understanding of that knowledge (Vranic & Martin, 2019). Cognitive processes involve various mental activities such as thinking, reasoning, memory, attention, problem-solving, language, and decision-making. These functions enable us to gather, retain, use, observe, reflect, and recall information effectively to navigate and engage with the world around us (Sellah et al., 2018; Jonassen & Grabowski, 2012). Padaria (2020) highlighted the importance of cognitive presence, how learners integrate concepts and theories within extension education, a construct that aligns with dimensions

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of cognitive style relevant to creative thinking. Cognitive style reflects the tone of behaviour rather than serving as a mediating process, representing an individual's way of functioning across different behavioural contexts (Coop & Sigle, 1971; McKenney & Keen, 1974; Botkin, 1974).

In this context, systematic and intuitive cognitive styles represent two key approaches individuals use for thinking, solving problems, and decision-making. Systematic Cognitive Style refers to a logical and structured way of thinking, where problems are solved or decisions are made step by step based on specific rules or data. In terms of characteristics, analytical and detail-oriented thinking are evident in this style. Systematic cognitive style relies heavily on logic or reasoning (Coop & Sigel, 1971; Buch, 1979). It demonstrates proficiency in planning and following processes. Reviewing all relevant information before making a decision is one of the hallmark traits of a systematic cognitive style. Intuitive Cognitive Style refers to a way of thinking where decisions are made based on experience, feelings, and intuition, with less reliance on structured analysis. In terms of characteristics, an intuitive cognitive style excels at quick decision making. It focuses on the big picture or overall context. It identifies patterns or a connection based on experience and often leans toward creative and innovative solutions. However, for success in life, maintaining a balance between the two styles is crucial, sometimes learning styles and career choices are interconnected (Kriti et al., 2025). Those who can effectively balance between two styles tend to achieve success more easily (Behera, 2022).

The research focuses on examining the cognitive style of students currently studying in college. After completing their college education, they will enter into a career contributing to the development of the nation. Thus, the academic success in college, soft skills and creative thinking will largely smooth their path in future life (Sikdar and Prakash, 2025). It also attempts to identify the relationship between the academic success of college students and their respective cognitive styles. Furthermore, the study seeks to estimate both systematic and intuitive cognitive styles among these students and examine how they vary by gender. It also aims to explore whether cognitive styles significantly relate to students' academic achievement and creative thinking. Identification of these patterns may help in developing region-specific insights for educators to design more effective, tailored instructional strategies, ultimately to support educational planning, psychological research, and policy development for enhancing student learning and well-being.

METHODOLOGY

The study adopted a descriptive survey approach to analyze how cognitive styles relate to academic success and creative thinking among undergraduate college students in the Sadar subdivision of West Tripura district; Tripura. The target group included all the undergraduate students who had completed their higher secondary school education. A total of 100 participants from 2 colleges (50 from each college) were selected using stratified random sampling, ensuring an equal distribution of male and female students to maintain gender balance and reduce sampling bias. The research included four null hypotheses: (1) Systematic cognitive style among students is not influenced by gender and gender does not have an effect on intuitive cognitive style; (2) Academic achievement does not significantly differ between students exhibiting systematic and intuitive cognitive styles; (3) Cognitive style and academic performance are not significantly correlated and (4) Systematic and intuitive Cognitive styles have no relationship with creative thinking. The key variables considered in the study were systematic and intuitive cognitive styles as independent variables, academic achievements and creative thinking as the dependent variables, and gender as a demographic factor. Data collection involved two standardized instruments, the first was the Cognitive Style Inventory (CSI-J), developed by Jha (2010), which evaluated how individuals process, judge, recall, store, and utilize information. It consisted of five subtests totaling 66 items presented on a 5-point Likert scale, with options ranging from "strongly agree" to "strongly disagree". The second tool was the "Creative Thinking Scale for college students (TWC)" developed by Mehdi (1985). This scale included four pretests, namely: Consequence Test, Unusual Uses Test, New Relationship Test, and Product Improvement Test. These tests were designed to evaluate an individual's capacity for divergent thinking, and the tool measures four core criteria (fluency, flexibility, originality, and creativity) designed to access students' creative potential across various domains. This scale provided a comprehensive view of creative thinking and is suitable for students from middle school to graduate level. During administration, the researcher first built rapport with the students to ensure they could express ideas freely and without hesitation. Clear instructions were delivered in simple and easily understandable language, and adequate time was provided for each test to encourage spontaneous and thoughtful responses. To ensure ethical standards, participants were informed about the purpose and the voluntary nature of the study. The collected data were subjected to both descriptive and inferential statistical analysis.

RESULTS

Degree of systematic and intuitive cognitive style among college students

Table 1 revealed that among those in the case of extremely high systematic cognitive style, females (16%) outperformed males (10%). However, male students demonstrated higher percentages at the high (16%), above average (20%), and average (28%) levels, compared to female students at 14%, 18% and 22% respectively. Female students recorded higher percentages at the below average level (24%) than males (20%), while at the low level, male students (6%) surpassed female students (4%). Notably, no male students were found in the extremely low category, but 2 per cent of the female students were in this category. Findings revealed that higher percentage of the college students stood at the below average, low, and extremely low levels, indicating that selected undergraduate students are lagging behind others.

The intuitive cognitive style distribution showed that male students exhibited a higher percentage at the extremely high level (14%) compared to female students (8%). Both genders of students recorded equal representation (10%) at the high level. At the above-average level, male students (28%) scored higher than female

Table 1. Level of cognitive style among college students based on gender

Category	Range of Z Score	Level	% Male (n=50)	% Female (n=50)
Systematic Style				
83 & above	+2.01 and above	Extremely high	10	16
75 to 82	+1.26 to + 2.00	High	16	14
68 to 74	+0.51 to +1.25	Above average	20	18
58 to 67	-0.50 to +0.50	Average	28	22
51 to 57	-0.50 to -1.25	Below average	20	24
43 to 50	-1.25 to -2.00	Low	6	4
42 & above	-2.01 and below	Extremely low	0	2
Intuitive Style				
87 & above	+2.01 and above	Extremely high	14	8
79 to 86	+1.26 to + 2.00	High	10	10
71 to 78	+0.51 to +1.25	Above average	28	22
60 to 70	-0.50 to +0.50	Average	20	26
52 to 59	-0.50 to -1.25	Below average	16	22
44 to 51	-1.25 to -2.00	Low	10	12
43 & above	-2.01 and below	Extremely low	2	0

counterparts (22%). In contrast, female students had a stronger presence at the average level (26%) compared to male students (20%). For the below average and low levels, female students scored 22 per cent and 12 per cent, slightly higher than males at 16 per cent and 10 per cent, respectively. Only male students (2%) were found at an extremely low level.

Role of systematic and intuitive cognitive styles on academic achievement

The analysis of academic performance revealed a noteworthy distinction between students with different cognitive styles. Learners exhibiting a systematic cognitive style demonstrated higher academic achievement, with a mean score of 75.6 (SD = 9.78), compared to their peers with an intuitive cognitive style, who averaged 72.08 (SD = 10.12). The computed t-value of 2.51 surpassed the critical value at the 5% level of significance, indicating that the observed difference in academic performance between the two groups is statistically significant.

Correlation between cognitive style and academic achievements

Table 3 further revealed a strong and statistically significant relationship between cognitive styles and academic performance. Students with a systematic cognitive style showed a robust positive correlation with academic achievement (r = 0.86), while those with an intuitive cognitive style also demonstrated a substantial positive correlation (r = 0.70). The corresponding t-ratio value was 16.68 for the systematic style and 13.57 for the intuitive style, which was exceeded the critical thresholds, confirming the statistical significance of both associations.

Relationship between cognitive style and creative thinking of college students

Table 4 represents correlation analysis undertaken to investigate the association between cognitive styles (systematic and intuitive) and multiple dimensions of creative thinking namely, fluency, flexibility, originality, and composite creativity scores among male and female undergraduate students. The findings revealed gender-specific patterns in the strength and significance of these associations. Among male participants, the systematic cognitive style demonstrated statistically significant, though modest, positive correlations with flexibility (r = 0.198, p< 0.05) and overall creativity (r = 0.205, p< 0.05). Although relationships with originality (r = 0.172) and fluency (r = 0.164) were observed, they did not reach statistical significance. In contrast, the intuitive cognitive style in males exhibited weaker associations across all

Table 2. Role of cognitive styles on academic achievement

Cognitive styles	n	Mean score of academic achievement	sd	df	't' value
Systematic cognitive styles	100	75.6	9.78	198	2.51*
Intuitive cognitive styles	100	72.08	10.12		

Note: *Significant at 5%; NS- Non Significant; df- degree of freedom; sd- Standard deviation

Table 3. Correlation between different cognitive style with academic achievement

Variable	No. of students (n)	'r' value	df	tr
Systematic cognitive style &academic achievement	100	0.86*	98	16.68
Intuitive cognitive style &academic achievement	100	0.70*	98	13.57

Note: *=Significant at 5%; r = Pearson correlation coefficient; tr = significance test of correlation; df = degrees of freedom

Table 4. Relationship between different cognitive style and creative thinking (n = 100)

Variables	Gender of the students	Systematic Cognitive Style	Intuitive Cognitive Style	Fluency	Flexibility	Originality	Creativity
Systematic Cognitive Style	Male	1	0.422**	0.164	0.198*	0.172	0.205*
	Female	1	0.445**	0.182	0.215*	0.190	0.222*
Intuitive Cognitive Style	Male	0.422**	1	0.148	0.118	0.188	0.157
	Female	0.445**	1	0.160	0.136	0.209	0.176
Fluency	Male	0.164	0.148	1	0.768**	0.734**	0.902**
	Female	0.182	0.160	1	0.785**	0.760**	0.925**
Flexibility	Male	0.198*	0.118	0.768**	1	0.742**	0.910**
	Female	0.215*	0.136	0.785**	1	0.765**	0.923**
Originality	Male	0.172	0.188	0.734**	0.742**	1	0.860**
	Female	0.190	0.209	0.760**	0.765**	1	0.878**
Creativity	Male	0.205*	0.157	0.902**	0.910**	0.860**	1
	Female	0.222*	0.176	0.925**	0.923**	0.878**	1

Note: M = Male students, F = Female students, *p < 0.05, **p < 0.01 (Significant correlation), Variables measured using Pearson's correlation coefficient (r), Creativity = Composite score of fluency, flexibility, and originality

dimensions, with the highest being with originality (r = 0.188), which remained statistically non-significant. In the case of female students, the associations between systematic cognitive style and creative thinking variables were slightly stronger and statistically significant for both flexibility (r = 0.215, p< 0.05) and overall creativity (r = 0.222, p< 0.05). Moreover, correlations with originality (r = 0.190) and fluency (r = 0.182) were marginally higher than those observed in the male cohort, though still not significant. The intuitive cognitive style among females was weakly associated with creative thinking dimensions, with the most notable correlations being with originality (r = 0.209) and creativity (r = 0.176), neither of which achieved statistical significance.

Notably, the strongest correlations emerged not with cognitive styles, but among the dimensions of creative thinking themselves. Across both genders, fluency and overall creativity exhibited a very strong positive correlation—r = 0.902 for males and r = 0.925 for females (both p< 0.01). Similarly, flexibility and creativity showed high correlation coefficients (r = 0.910 for males, r = 0.923 for females, p< 0.01), while originality also correlated strongly with overall creativity (r = 0.860 for males, r = 0.878 for females, p< 0.01). These findings suggest that while cognitive style, particularly the systematic type, bears some influence on creative thinking—especially in terms of flexibility and total creativity score—the internal dimensions of creativity are far more strongly interrelated, reflecting a cohesive cognitive construct across genders.

DISCUSSION

The study reveals notable gender-based patterns in cognitive styles (Alalouch, 2021) and cognitive styles plays an important role in academic achievement, similar results also identified by Amin et al., (2023) & Singh et al., (2020). Although more female students appeared at the extremely high level of systematic cognitive style, male students generally performed better in the combined high to average range. The higher proportion of female students at the below average and extremely low levels indicates variability in their cognitive performance, suggesting a need for targeted support programs. These trends align with findings of Halpern (2012) & Hyde (2014), who noted that males tend to demonstrate more consistent cognitive patterns, while females show more variability. Giancola et al., (2022) found that field-independent individuals, who tend to process information independently of surrounding context, performed significantly better on visual creative tasks than field-dependent peers, underscoring cognitive style as a foundational component in creative output. With regard to intuitive cognitive styles, male students showed higher percentages at the extreme and above average levels, suggesting stronger intuitive abilities in certain contexts. However, female students demonstrated more consistency around the average level. This finding reflects research by Phillips et al., (2004), which emphasized that male student may excel in rapid, intuitive tasks, while female students maintain a more balanced cognitive profile. The lack of statistically significant differences in systematic and intuitive cognitive styles between the genders supports the view that cognitive styles are shaped more by environmental and educational factors than by biological sex (Zhang & Sternberg, 2005; Vera, 2024). The observed differences in distribution may be attributed to socio-cultural influences and individual learning experiences. The significant advantage of systematic cognitive style over intuitive style in terms of academic performance suggests that a structured, analytical approach enhances academic outcomes. This reinforces and emphasizes the role of systematic thinking in achieving academic success (Talat, 2017; Nadaf et al., 2019). Alalouch (2021), found gender and students clarity about their cognitive style were the best predictors of academic performance. Furthermore, the strong positive correlation between both cognitive styles and academic achievement underscores the importance of cognitive development in educational planning. Hussin et al., (2021) found a statistically significant relationship between cognitive style and academic performance. Students with well-developed systematic or intuitive styles tend to perform better academically, confirming that cognitive flexibility and clarity in thought processes contribute positively to learning outcomes (Cools & Van den Broeck, 2007).

The findings also indicate a positive association between cognitive style and creative thinking among college students. Both male and female students with systematic cognitive style exhibited

stronger correlations with creative thinking components compared to those with intuitive style, similar results also identified by Taneja et al., (2023); Ho & Kozhevnikov (2023). Further, female students consistently demonstrated slightly higher correlation coefficients between systematic cognitive style and creative thinking dimensions than male students. This suggest that females derive more creative advantage from structured, logical thinking processes and the findings aligns with previous literature emphasizing the growing role of cognitive regulation and structured thought in female academic and creative success (Hyde, 2014; Zhang & Sternberg, 2005). The strong inter-correlations between fluency, flexibility, originality and creativity reinforce the view that these dimensions are synergistic and collectively define creative capacity (Bellemare Pepin & Jerbi, 2024). These findings provide empirical support for educational strategies that encourage integrated development of both cognitive styles, especially emphasizing systematic approaches to enhance creative potential in students. In conclusion, the results emphasize the need for a balanced cultivation of systematic and intuitive cognitive abilities to support creative thinking, with a tailored focus on gender-responsive pedagogical interventions.

CONCLUSION

The study establishes that cognitive styles, particularly the systematic type, are significantly associated with academic achievement and creative thinking among college students. Both systematic and intuitive styles demonstrate positive correlations with academic performance; however, the systematic style is significantly linked to higher achievement and enhanced creative capacities, especially in flexibility and overall creativity. Although gender based differences in cognitive styles were not statistically significant, the observed variation in distribution highlights the need for differentiated instructional strategies. The findings underscore that cognitive development, rather than gender, plays a more decisive role in academic and creative outcomes. From an extension education perspective, these insights are valuable for designing learner-centric programmes that acknowledge individual thinking patterns. Educational planners, faculty, and extension professionals should integrate cognitive style awareness into curriculum development and capacity-building initiatives to enhance student engagement and performance. By fostering both systematic and intuitive thinking abilities, institutions can create more inclusive and effective learning environments that support holistic student development. Consent of Publication: Participants provided consent for publication

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Research Article

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Digital Shift: How increased Digital Exposure is Reshaping Adolescents Lifestyle?

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HIGHLIGHTS

- Adolescents spend significant time on digital gadgets, with screen time increasing on holidays.
- Boys and girls engage in different activities after school, with girls preferring indoor activities.
- Prolonged screen time interferes with personal relationships and face-to-face interactions among adolescents.
- Excessive use of digital devices was associated with stress, antisocial behavior, and poor dietary habits.
- The amount of time spent on digital gadgets affects adolescents' lifestyles and behaviors.

ARTICLE INFO

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ABSTRACT

The study was conducted in 2025 to investigate the amount of time adolescents spent on digital devices and its impact on their lifestyle on 300 participants, ranging from 14 to 16 years of age, possessing digital devices in their homes or owned one by them. The findings revealed significant differences between boys and girls regarding activities performed after school. The adolescents were not utilizing digital devices for academic purposes after school hours. The duration of these activities increased during holidays. Adolescents made daily adjustments in their lives to allocate more time to digital devices and conversations with friends. The frequency of use on working days and changes in the duration of these activities during weekends showed significant differences among adolescents. Findings revealed that the participants encountered various lifestyle changes such as anti- social behavior, stress, laziness, tiredness, limited physical interaction, and digital relationships due to prolonged engagement with digital devices. The results of the study demonstrated a positive relationship between lifestyle changes and excessive time spent on digital devices. The findings can assist teachers, educational institutions, policymakers, and counsellors in promoting healthy screen time.

INTRODUCTION

The increasing prevalence of digital devices in daily life has raised concerns about their impact on the lifestyle and well-being of adolescents. This widespread use has led to debates about their potential negative effects on physical health, mental well-being, and social interactions. Research in this area aims to understand the complex relationship between digital technology use and various aspects of adolescent development.

The use of digital media offers both benefits and risks, including early learning opportunities and increased social contact, but also negative impacts on sleep, focus, learning, and an increased rate of obesity and depression (Chassiakos et al., 2016). Notably, the COVID-19 pandemic has intensified these impacts. Although there were initial reductions in irritability and negative digital experiences during remote education, these effects eventually returned to or surpassed their original levels when schools reopened, accompanied by increases in digital media use and stress (Nutley et al., 2023). However, not every form of digital media usage had negative effects on the mental well-being of adolescents. Direct communication and positive interactions online helped alleviate feelings of loneliness and stress during the pandemic (Marciano et

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al., 2022). The impact of digital devices on adolescents extends beyond individual health concerns to broader societal implications, including changes in educational practices and family dynamics. As teenagers spend more time engaged with digital technology. Pandey et al., (2020) explores social media usage among college students and highlight rampant usage of social media in which WhatsApp and Facebook are the most used social platforms. There is a growing need to investigate the long-term consequences on their cognitive development, social skills, and academic performance. The outcomes of past studies have shown a relationship between prolonged digital exposure and various negative health outcomes, such as obesity, sleep disturbances, and decreased physical activity among adolescents. Studies indicate that teenagers engage with the Internet more often than adults and utilize it for a wider range of purposes compared to other age groups (Cain & Gradisar, 2010; Livingstone et al., 2011; O'Keeffe et al., 2011; Tzavela et al., 2015, Casaló & Escario, 2018). These internet driven gadgets transformed students' education and learning, the pattern of making friends and maintaining these social relationship, time spent on leisure activities, and their community involvement. Singh et al., (2024) concluded that college students had a positive perception towards e-learning. Meinam et al., (2023) found that students were influenced by TV, radio, social media, and other media for their career choices along with their parents. Although there are opportunities, adolescents may encounter harmful or unsettling material, face internet victimization or online hate, and be at risk of identity theft, unwanted sexual advances, and sexual predation (Kuss et al., 2013; Weaver et al., 2011; Yakovlev & Kinney, 2008). Early exposure to screen media can have long-lasting effects, with excessive toddlerhood televiewing associated with less optimal health and behavioral dispositions in adolescence (Simonato et al., 2018). This widespread internet usage among youth underscores the importance of understanding and addressing online risks for adolescents.

METHODOLOGY

Rewari district from Haryana was selected based on its demographic characteristics and relevance to the research objectives. A single block was chosen using purposive sampling which consisted of 39 villages. The chit system was employed to ensure a random selection of villages from which schools were selected using the chit system. This method involved writing the names of all villages on identical slips, mixing them thoroughly and drawing slips randomly until the required number of villages was selected. A similar process was followed to select the schools. This ensured an unbiased selection process. Three hundred participants from 14-16 years of age were approached from different selected school. Prior permission was taken from the principals of the schools and only participants who expressed interest in the study were included. For this research, ethical approval was obtained from the ethical committee (H.Sc./EC/027/24.02.2023).

This article describes a study that adhered to ethical research standards by involving adolescent participants under 18 years age. Before engaging in the research, the study obtained informed consent from parents or legal guardians of each participant. The parents issued written consent forms detailing the study's objectives, methodologies, and data collection procedures. These consent forms also stressed that participation of their children is voluntary and they can withdraw at any time without facing negative repercussions. To ensure privacy, all collected information was treated confidentially and anonymized for analytical purposes.

A questionnaire was constructed and validated by the researcher to gather information on screen time exposure and the lifestyle changes they faced due to excessive screen time. The validity and reliability of the questionnaire was checked through Cronbach's alpha and obtained the value 0.8 suggesting a reliable range score. The questionnaire used was clear and easy for participants to answer. It was also reviewed by subject experts for appropriateness and to their valuable inputs were incorporated to make it more suitable for the study. Questionnaire was distributed to the participant during school hours. Approximately 25-30 minutes were allotted to complete the questionnaire. The researcher explained to the participants how to fill the questions and these questions had to be answered in the questionnaire itself by the respondents to ensure their responses were not affected by any third person's presence. The data was collected and the outcomes of the study were analyzed using Statistical Packages for Social Sciences (SPSS 16.0).

RESULTS

As shown in the above Table 1, significant differences were observed in various aspects of digital exposure among boys and girls i.e. activities performed by the students after coming from school (3.4), time spent on digital gadgets during holidays (2.4), their everyday adjustments to spend more time in front of screen (2.4) and conversation with friends over phone calls (3.10).

Table 1. Screen Time Exposure among adolescents

Screen time exposure	Boys (n=150)	Girls (n=150)	Z - Value	P- values
	Mean ± SD	Mean ± SD		
Play games	1.9±.83	1.9±.82	0.7	0.94
Activities after school	2.5±.87	2.1±.99	3.4**	0.001**
Frequency of activities	2.3±1.0	2.5±1.1	1.4	0.13
Duration in working days	1.7±.82	1.7±.88	0.1	0.89
Duration on holidays	1.4±.51	1.3±.46	2.4*	0.01*
Change during holidays	1.9±1.0	1.7±.85	1.6	0.10
Adjustments to use gadgets	2.5±1.1	2.2±.1.0	2.4*	0.01*
Use of social media	2.8±1.2	2.8±.1.2	0.1	0.92
Talk to friends on smartphone	1.7±1.06	1.3±0.85	3.10**	0.002**

*p=0.05, **p=0.01

In Table 2, ANOVA (F test) through SPSS 16.0 was computed about various domains of screen time exposure based on the age group of respondents. Statistically significant differences were observed in activities performed by the participants after coming home from school (4.28), frequency of these activities on digital gadgets (3.03); and change in the duration of the activities participants executed on holidays. The findings of the study showed no significant differences in other aspects of screen time exposure in relation to the age of the respondents.

Table 3 depicts lifestyle changes among boys and girls due to excessive use of digital gadgets using an independent sample z-test. The outcomes of the study shows statistically significant differences in various aspects i.e. use of gadgets in toilet (2.42), tiredness during daytime due to late night usage of digital gadgets (1.94), duration of conversation with friends and family on social media (2.14) and smoking behavior (0.72) among students. The other aspects did not show significant differences among adolescent boys and girls.

Table 4 expresses a relationship between digital exposure and lifestyle changes of adolescents. The results revealed that the duration of digital gadgets usage among adolescents on weekdays (r= 0.20) has a positive correlation with the changes in lifestyle. If they were spending more time on the gadgets, it led to behavioral problems like, anger, stress, anxiety etc. There was a positive relation between change in these activities in front of gadgets on holidays and their lifestyle (r=0.1). On holidays, they had more time to do leisure activities due to which lifestyle patterns of adolescents also affected. Increased duration of screen usage during weekends and changes in adolescents' lifestyle expressed positive relationship (r=0.22). More the time adolescents watch gadgets

Table 4. Correlation between Screen Time Exposure and Lifestyle Changes among Adolescents

	Life style changes	
	Correlation coefficient (r)	P-value
Use digital gadgets to play games	-0.21	>0.05
Activities perform after school hours	0.09	>0.05
Frequency of these activities	-0.03	>0.05
Duration of these activities in a working day	0.20**	<0.01**
Change on holiday	0.1*	<0.05*
Increase in hours on holiday	0.22**	<0.01**
Adjustments to use gadgets	0.44**	<0.01**
Type of content on screen	0.36	>0.05

p=0.05, **p=0.01

Table 2. Comparison of Screen Time Exposure as Per Age

Age group →	14 years	15 years	16 years	F- values	P-values
Screen time exposure ↓	Mean ± SD	Mean ± SD	Mean ± SD		
Play games	1.9±.77	1.9±.85	2.0±.85	0.89	0.41
Activities after school	2.3±.92	2.1±.95	2.5±.95	4.28*	0.01*
Frequency of activities	2.3±1.0	2.6±1.0	2.3±1.1	3.03*	0.05*
Duration in working days	1.7±.85	1.7±.86	1.7±.89	0.14	0.86
Duration on holidays	1.3±.51	1.4±.49	1.3±.46	1.54	0.21
Change during holidays	1.7±.88	2.0±1.03	1.7±.85	3.79*	0.02*
Adjustments to use gadgets	2.5±1.1	2.3±1.0	2.4±1.1	0.80	0.44
Use of social media	2.8±1.2	2.7±1.3	2.9±1.1	1.27	0.28

*significant at 5% level of significance

Table 3. Lifestyle Changes among Adolescents

Lifestyle changes	Boys (n=150)	Girls (n=150)	t- Values	P- values
	Mean ± S.D.	Mean ± S.D.		
Limit physical activities	1.8±0.80	1.8±0.83	0.21	0.83
Using gadgets while eating	1.9±1.02	1.9±0.99	0.62	0.53
Postpone eating	1.9±1.09	1.7±0.97	1.61	0.10
Neglect using toilet	1.9±1.07	1.7±0.91	1.79	0.07
Using gadgets in toilet	1.5±0.74	1.3±0.68	2.42*	0.01*
Loose sleep	2.6±1.25	2.4±1.29	1.85	0.06
Feel tired	2.9±1.23	2.6±1.25	1.94*	0.05*
Excessive use cause stress	3.3±1.30	3.2±1.25	1.17	0.24
Laziness	3.0±1.31	3.2±1.25	1.25	0.21
Physical exercises	2.4±0.75	2.3±0.72	0.85	0.39
Shout & angry	2.3±1.06	2.3±1.13	0.21	0.83
Friends on social media	2.1±1.15	1.8±1.16	2.14*	0.03*
Stress when gadgets don't work	2.5±1.10	2.4±1.12	0.72	0.47
Spent more money	2.4±1.07	2.3±1.16	0.56	0.57
Anti-social behavior	2.6±1.12	2.5±1.27	0.43	0.66
Smoke	2.5±0.76	2.8±0.56	0.72*	0.000***

*significant at 5% level of significance

there are more chances that they get trapped into addictive disorders and their day to day life adjustments to spend more time on these gadgets (r=0.44) were correlated with the changes in the lifestyle of adolescents. The findings showed that use of gadgets to play games, activities performed by the adolescents after school hours, frequency of these activities and type of content were negatively correlated with the lifestyle of adolescents.

DISCUSSION

It was observed that type of activities they perform when they return to home after their school hours include outdoor games, indoor games, online gaming or playing with siblings. Both boys and girls perform different activities after returning from school. Girls are mainly involved in indoor activities while boys were more opportunities to play outside. A British study showed patterns of screen usage among adolescents in a week that is going to rise from 8.1 hours to 15.2 hours in boys and 6.1 hours to 15 hours in girls (Atkin et al., 2013). Adolescents prefer to talk over phone calls and messaging apps rather than face-to-face interaction with each other. Results are potentially congruous with the preceding study which expressed that social networking platforms and virtual conversation with family and peer group may also have distinctive impacts on boys and girls. Adolescent girls may be more inclined to engage in social comparison and more likely to seek feedback on social media (Nesi & Prinstein, 2015). Girls also spend more time on social media than boys (Yau & Reich, 2018). As per Ahn & Shin (2013) and Dienlin et al., (2017) a key question arises: Does smart phone communication actually result in a decline in physical meetings? As per the social displacement assumption, physical gatherings are replaced by the digital interconnections. This would imply that adolescents, spending more time on theses digital devices for their socialization, do not involve themselves in face-to-face social relations.

The second aim of this paper is to assess the lifestyle changes due to excessive screen time among adolescents. Individuals face some major changes in their lives when they start using digital devices for long hours in a day. Prolonged exposure to these devices causes stress, antisocial behavior, faulty dietary habits, fewer interactions with others and tiredness. Use of digital gadgets like smartphones in toilets is more prevalent in boys than girls. Several publications support the study by emphasizing the probable negative outcomes associated with excessive use of digital devices. In the field of medicine, a new finding came in light which was neglected previously. Prolonged exposure to digital gadgets was associated with hemorrhoids (Berney, 2020). An assessment conducted on university students indicated that students younger than twenty three years, i.e. Generation Z use their smartphones while using toilets. The Students go inside washrooms along with smart phones were titled as "young adults who are glued to their digital devices" (Berney, 2020; Leng, 2016). Usage of handheld devices in bathrooms is an emerging etiology of hemorrhoid disease that has long term consequences on the quality of life. This is a type of disorder which is known as "Smart phones' lavatory syndrome". People with this disorder spend more time in toilets which exerts supererogatory pressure on certain parts of the body like pelvic floors, lower rectum and anal region. It also causes problem while defecating. The chances of hemorridal diseases increase when an individual sits for more than 20-30 minutes per defecation (Berney, 2020). The results revealed that over use of screens during night time causes tiredness in day time among adolescents especially in schools. This is also responsible for lack of concentration on academics which results into poor performance in studies. A study carried out by Chang et al., (2014) supports these finding explaining that late night exposure to screen leads to sleepiness during daytime which ultimately affect academic performance of adolescents. Excessive use of digital devices is responsible for insomnia that is linked with daytime tiredness and sleepiness (Gruber et al., 2014; Owens, 2014). Similar findings were shared by Merdad et al., (2014) that the widespread presence of sleep disturbance at night causes excessive daytime sleepiness among adolescents.

The results expressed that the duration of time adolescents spend in front of screens affects their life. The findings are consistent with the study of Stiglic and Viner (2019) who found in their research that early addiction to screens persist throughout the life and tend to mess with other deleterious lifestyle behaviors such as poor dietary habits, sleeping disorder, depression, ADHD and so on. Parent et al., (2016) supports the study that the total daily screen time on various devices had heightened from 5 hours/day in 1996 to 8 hours/day now.

CONCLUSION

Digital exposure significantly influences the lifestyle of adolescents shaping their social life, mental well-being, and their everyday habits. The girls spent more time on digital gadgets than boys because boys tend to participate in outdoor activities while girls live most of the time at their home. Duration of digital exposure and change in screen time on holidays and conversation on digital gadgets contribute to their life style changes among adolescents. Habits of students such as using of gadgets especially smart phone in toilet, and late night digital exposure induced tiredness during the school time. Lifestyle of adolescents was positively correlated with activities and duration of these activities. Time spent on gadgets and increase in their duration led to lifestyle changes in adolescents. Adjustments made by adolescents to perform digital activities also affect their lives. Digital literacy and moderate use of gadgets will be beneficial for their all round development.

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Research Article

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Mapping Socio-economic and Entrepreneurial Diversity among Makhana Farmers in Bihar through Cluster Analysis

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HIGHLIGHTS

- Three distinct clusters of makhana farmers were identified, each with unique socio-economic and behavioural characteristics.
- Significant differences were found in landholding, annual income, and Makhana income across the clusters.
- Young and resource-limited farmers showed higher entrepreneurial traits, indicating their potential for targeted intervention.

ARTICLE INFO

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ABSTRACT

Makhana (*Euryale ferox*), a high-value aquatic crop, plays a pivotal role in the rural economy of Bihar, particularly in the Mithilanchal and Kosi regions. However, the socio-economic characteristics of makhana farmers are far from homogeneous, reflecting diverse livelihood strategies, access to resources, and market participation levels. The study presents a replicable protocol to classify socio-economic and entrepreneurial diversity among makhana farmers. A multistage stratified random sampling technique was used to collect primary data from 120 farmers across four major districts of Bihar during 2022-23. Ward's hierarchical clustering followed by k-means clustering identified three statistically distinct groups based on landholding, income, and entrepreneurial indicators. ANOVA and Levene's tests confirmed significant variation across the clusters. The findings support the development of targeted, group-specific extension strategies. The proposed framework serves as a replicable protocol for classifying farmer heterogeneity in similar agricultural contexts. The analysis revealed three distinct clusters of farmers viz., Well-capitalised Makhana Farmers, Progressive and Prosperous Farmers, and Traditional, Medium-Level Farmers–each with unique characteristics and development needs. The findings support the development of targeted, group-specific extension strategies. The proposed framework serves as a replicable protocol for classifying farmer heterogeneity in similar agricultural contexts.

INTRODUCTION

Popped makhana (foxnut) seeds – the edible product of *Euryale ferox* is an aquatic crop cultivated primarily in Bihar. These high-protein, low-fat nuts have gained superfood status globally. Bihar accounts for over 90 per cent of India's makhana production and approximately 85 per cent of global output (Singh & Agrawal, 2024). The Kosi and Mithlanchal region, including districts like Purnia, Katihar, Madhubani and Darbhanga, is a dominant zone for makhana cultivation due to its waterlogged conditions and traditional knowledge systems (Sonu & Jha, 2025). Globally, makhana (*Euryale ferox*) is estimated to secure a valuation of USD 146.6 million in 2025 and is estimated to rise to USD 265.4 million by 2035. The market is anticipated to grow at a CAGR of 8.1 per cent during the forecast period (Future Market Insights Global, 2025). The Government of India has responded by announcing a "Makhana Board" for Bihar (2025 budget) and creating a GI tag for Mithila Makhana (2022) to improve processing, value addition and export potential (Times of India, 2025).

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The total area under Makhana cultivation in India is around 15,000 hectares (ha), with an average production of 1.5 tonnes per hectare (t ha^{-1}). The total production of Makhana seeds is around 1,20,000 million tonnes (MT), which after processing becomes 40,000 MT of Makhana pop. Makhana production is projected to be worth Rs. 2.50 billion at the farmer's level, however, it earns Rs. 5.50 billion at the trader's level (Sonu & Jha, 2025). In Bihar, the area under Makhana cultivation is about 13,000 ha, contributing to 85 per cent of India's total production. Major producing districts include Darbhanga (7421.4 t), Sitamarhi (277.4 t), Madhubani (7280.7 t), Saharsa (5267 t), Supaul (5182.8 t), Araria (2639.95 t), Kishanganj (2000.25 t), Purnia (11652.9 t), and Katihar (11759 t). Darbhanga and Madhubani districts alone account for approximately 80 per cent of the processed Makhana production (Ahmad, 2020).

The agricultural sector in Bihar, India, exhibits significant socio-economic diversity, particularly among makhana (*Euryale ferox*) farmers, who play a crucial role in regional food security and rural livelihoods. Makhana cultivation, primarily practised in the floodplains of North Bihar, contributes substantially to the local economy but is marked by disparities in landholding, income, education, and access to resources. Understanding the dynamics of these heterogeneities is essential for designing targeted policies, improving resource allocation, and enhancing farmers' welfare. However, existing studies often treat makhana farmers as a homogeneous group, overlooking the nuanced variations that influence their productivity and decision-making (Singh & Pandey, 2020).

Specifically, the study aims to categorise farmers using key variables such as landholding size, annual income, education level, and family size. These variables were selected based on previous research highlighting their significant influence on agricultural adoption and livelihood outcomes (Sonu & Jha, 2025). To achieve this classification, cluster analysis–a statistical method capable of grouping similar observations while maximising differences between groups–was employed (Everitt et al., 2011). This approach allows identification of latent patterns in the heterogeneous population, thus enabling more effective policy formulation and extension strategies tailored to the needs of distinct farmer.

METHODOLOGY

The study was conducted during the period 2022–24 in four major makhana-producing districts of Bihar, namely Darbhanga, Madhubani, Katihar, and Purnea. These districts were selected purposively due to their concentration of makhana cultivation and their representativeness of regional agro-ecological and socio-economic diversity. A multistage stratified random sampling technique was employed to select 120 makhana farmers, ensuring representation across key strata relevant to the study area. The strata were defined based on the highest production blocks (Purnea East from Purnia, Barari from Katihar, Bahadurpur from Darbhanga, and Jhanjharpur from Madhubani), Proportional samples were drawn from each stratum corresponding to their population share, which helped capture the diversity of farming practices and socio-economic conditions among makhana cultivators in the region. Primary data were collected from the sampled respondents using a pre-tested semi-structured interview schedule. The interview schedule encompassed a broad range of variables, including demographic characteristics, economic indicators, knowledge levels, and entrepreneurial indicators (innovativeness, achievement motivation, production orientation, marketing orientation, risk-taking ability, and management orientation). To explore and classify the socio-economic diversity among makhana farming households in Bihar, a two-stage cluster analysis approach was adopted. In the first stage, Ward's hierarchical clustering method was applied to minimise within-cluster variance and determine the optimal number of clusters (Murtagh & Legendre 2011). Ward's method, a widely used agglomerative clustering technique, operates by minimising the total within-cluster variance at each step of the clustering process. The application of this method resulted in a dendrogram that provided a hierarchical visualisation of how the sampled farmers were grouped based on their socio-economic and behavioural characteristics. The dendrogram also aided in identifying the optimal cluster solution by pinpointing the stage with the greatest increase in linkage distance. Following this, the k-means clustering method–a non-hierarchical partitioning approach–was employed to refine the classification by assigning farming households to clusters based on their proximity to the respective cluster centroids (Burkardt, 2009). The integration of both Ward's method and k-means clustering ensured that the final clusters were internally homogeneous and externally heterogeneous. To validate the robustness of the cluster solution, one-way ANOVA was performed to test for statistically significant differences across the clusters in terms of key socio-economic variables. Additionally, Levene's test was applied to assess the equality of variances among the groups (Fox & Weisberg, 2019). This comprehensive and statistically grounded methodology facilitated the identification of distinct categories of makhana farmers, thereby enabling targeted policy formulation and effective intervention strategies.

RESULTS

The vertical axis in Figure 1 represented the dissimilarity or distance between clusters that were merged. A greater height on this axis indicated more heterogeneity between the clusters joined at that point. Initially, each farmer appeared as an individual unit at the base of the dendrogram. As the clustering algorithm progressed upward, these individual farmers were gradually grouped into larger clusters. At a specific height–around 15–a horizontal cut in the dendrogram revealed three distinct clusters, shown within red, green, and blue boxes. This grouping matched the earlier k-means clustering, where the number of clusters (k) was set to three. The branching patterns in the dendrogram clearly showed significant variability among the farmers, especially since the vertical distances between some merges were large at the top of the tree. This indicated that the farmer groups formed were not only statistically distinct but also meaningful in terms of their socio-economic characteristics.

Figure 2 revealed K-means clustering of the 120 makhana sampled farmers from three distinct groups. Cluster 1 (circle) comprised only a few farmers, but they stood out by having markedly different socio economic profiles: these farmers tended to have the smallest landholdings and the lowest annual and makhana incomes among the sample. In contrast, Cluster 2 (triangle) contained farmers

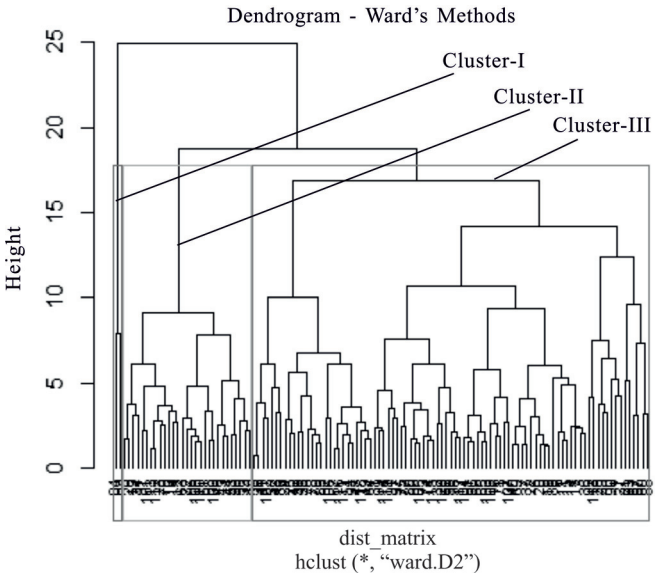

Figure 1. Dendrogram of socio-economic heterogeneity among makhana farmers in Bihar using Ward's method

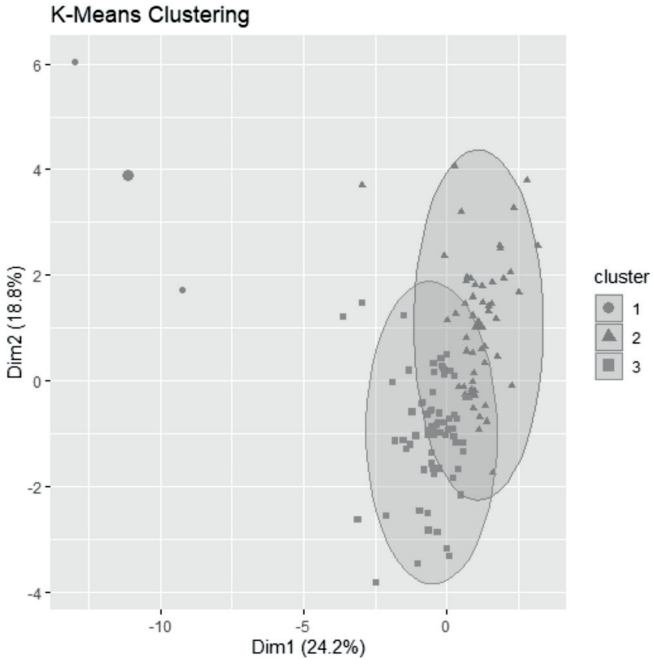

Figure 2. K-Means Clustering diagram of socio-economic heterogeneity among makhana farmers in Bihar

with larger landholdings and the highest mean annual and makhana incomes, suggesting they are relatively better off; this group also had higher average knowledge scores. Cluster 3 (rectangle) fell between these extremes, with moderate land size and incomes.

Cluster 1: Well-capitalised Makhana Farmers (N = 2)

Cluster 1 represented a small group of farmers (just 2 out of 120), characterised by extremely high landholding and income values, making them extreme outliers within the dataset. These farmers had an average landholding of 77.5 ha, which is nearly 20 times larger than the average for other clusters. Their average annual income was Rs. 2.14 million, and makhana income was Rs. 2.085 million, indicating heavy reliance on and success in makhana-based agriculture. Despite their exceptional economic standing, these farmers showed very low educational attainment (average: 0.5 years of schooling)—suggesting that success in this context may not be education-driven but could be due to inherited land assets, long-standing experience, or specialised knowledge not captured by formal education. Demographically, these farmers were also significantly older (average age: 67.5 years), and they had the largest family sizes (average: 8.5 members), likely contributing to labour availability on their large landholdings. Their entrepreneurial traits showed moderate scores across indicators such as knowledge (29), innovativeness (19.5), and perception (9), though their perception score was notably lower than in other clusters. These traits might reflect traditional but successful farming methods with limited openness to new ideas. Statistical tests confirmed that this cluster was significantly different from the others in terms of landholding and income ($p < 0.001$), but not in education ($p = 0.172$). However, due to the small number of observations, generalisations must be made cautiously. Nonetheless, this cluster illustrates the presence of a niche group of elite farmers who dominate makhana production economically but are not necessarily formally educated or highly innovative.

Cluster 2: Progressive and Prosperous Farmers (N = 53)

Cluster 2 comprised the most populous and economically well-off group among the mainstream farmers. These farmers had moderate to high landholding sizes (mean: 3.75 ha) and were characterised by the highest average scores in multiple entrepreneurial and psychological dimensions, including knowledge (24.7), innovativeness (21.5), achievement motivation (19.4), and perception (12.77). Their annual income averaged Rs. 1,36,000, and income from makhana was Rs. 85,293, placing them above average but not in the elite bracket of Cluster 1.

The farmers in this cluster were relatively young and had small-to-moderate family sizes (5.85 members), possibly indicating a shift toward nuclear families or a focus on economic efficiency. Educational attainment was moderate (average: 1.62 years), though still low in absolute terms, and not significantly different from other clusters (ANOVA $p = 0.172$). Interestingly, despite the low formal education, their higher entrepreneurial traits suggested a willingness to adopt innovations and scientific practices, contributing to higher productivity and income. In terms of the distribution of districts, this cluster included significant membership from Madhubani (18), Katihar (14), and Darbhanga (12), with a smaller representation from Purnea (9). The concentration of such farmers in these districts indicated regional pockets of progressive farming practices and better access to markets, infrastructure, or support services. ANOVA tests revealed that Cluster 2 differed significantly from Clusters 1 and 3 in landholding ($p < 0.001$), annual income ($p < 0.001$), and makhana income ($p < 0.001$). Levene's test also confirmed heterogeneity of variance in these variables ($p < 0.01$), implying that variability in farm size and income was high even within this relatively uniform group. This cluster is vital for targeted interventions as these farmers represent the future of scalable and sustainable makhana entrepreneurship.

Table 1. Characteristics of Selected Clusters of Farm Households and P-value of one-way analysis of variance

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster Mean	Cluster SD	P-Value
Age	67.5	43.58	45.85	52.31	13.20	<0.001
Education	0.5	1.62	1.27	1.13	0.57	0.172
Family Size	8.5	5.84	7.36	7.23	1.33	-
Land Holding	77.5	3.75	4.22	28.49	42.44	<0.001
Annual Income	2144250	135727.2	148705.90	809561	1155892.8	<0.001
Makhana Income	2084750	85293.25	94444.38	754829	1151754.3	<0.001
Scientific Orientation	17.5	16.33	16.50	16.77	0.63	-
Perception	9	12.77	11.76	11.17	1.95	-
Knowledge	29.0	24.69	25.00	26.23	2.40	-
Entrepreneurial Behaviour						
Innovativeness	19.5	21.54	20.95	20.66	1.04	-
Achievement Motivation	16.0	19.35	16.60	17.31	1.78	-
Production Orientation	17.0	20.49	17.60	18.36	1.86	-
Marketing Orientation	22.0	22.83	21.64	22.15	0.61	-
Risk-taking ability	16.0	19.35	16.66	17.33	1.77	-
Management Orientation	22.0	22.86	21.64	22.16	0.62	-

Cluster 3: Traditional, Medium-Level Farmers (N = 65)

Cluster 3 included a relatively large group of farmers who may be considered typical or average makhana growers. They had moderate landholdings (mean: 4.22 ha) and earned Rs. 1,49,000 annually, with makhana income averaging Rs. 94,444, which was relatively higher than Cluster 2 in this regard, despite lower entrepreneurial traits. Their educational level was 1.27 years on average, and their family sizes were higher (7.37 members), possibly suggesting a reliance on traditional family-based labour systems.

Farmers in this cluster were slightly older (mean age: 45.6 years) than those in Cluster 2 but much younger than Cluster 1, representing a transitional generation. Entrepreneurial indicators were relatively modest: knowledge (25), innovativeness (20.95), achievement (16.6), and perception (11.77), indicating a group with decent traditional knowledge but less proactive behaviour toward innovation or risk-taking compared to Cluster 2. Scientific orientation and risk management scores were also moderate. District-wise, this group largely represented Purnea (19) and Darbhanga (18), suggesting these regions are home to many farmers who maintain traditional practices with limited external support. These farmers may benefit from targeted training or extension programs designed to improve access to modern cultivation and marketing techniques. Like Cluster 2, this group showed significant variation in income and landholding ($p < 0.001$) compared to others, but not in education. Levene's test supported significant variance differences, particularly in income and land size.

The one-way ANOVA was conducted to examine whether there were statistically significant differences in landholding, annual income, makhana income, and education levels among the identified clusters shown in Table 2. The results indicated significant differences between clusters for landholding (217.1, $p < 0.001$), annual income (265.3, $p < 0.001$), and makhana income (271.5, $p < 0.001$). These findings suggest that the clusters differ substantially in terms of landholding size and income variables, both overall and specifically from makhana production. In contrast, no significant difference was found among clusters for education levels (1.79, p = 0.172), indicating that educational attainment was relatively homogeneous across the groups.

Table 3. Levene's test of socio-economic heterogeneity among makhana farmers in Bihar

Variables	F value	P Value	Significance
Land Holding	5.851	0.003	Significant
Annual Income	6.947	0.001	Significant
Makhana Income	7.671	0.000	Significant
Education	0.279	0.757	Non-Significant

Table 3 demonstrated that Levene's test rejected the null hypothesis of equal variances for Land Holding, Annual Income and Makhana Income, but not for Education. Specifically, Land Holding ($F = 5.851$, $p = 0.003$), Annual Income ($F = 6.947$, $p = 0.001$) and Makhana Income ($F = 7.671$, $p < 0.001$) all yielded p-values well below the 0.05 threshold. By convention, this indicates significant variance heterogeneity among the clusters for these variables. In contrast, Education ($F = 0.279$, $p = 0.757$) reflected a high p-value (>0.05), so the null hypothesis of homogeneity of variance was not rejected for education. In practical terms, a significant Levene test ($p<0.05$) means at least one cluster's variance differs from the others whereas a non-significant result means variances are statistically indistinguishable. Thus, the clusters of makhana farmers were markedly heterogeneous in landholding and income (the dispersion of these traits differs across clusters) but homogeneous in educational attainment.

Table 4 revealed that the entrepreneurial profiling of makhana farmers revealed notable variation across six key attributes. Among

Table 2. ANOVA of socio-economic heterogeneity among makhana farmers in Bihar

Variables	F value	P Value	Significance
Land Holding	217.1	<0.001	Significant
Annual Income	265.3	<0.001	Significant
Makhana Income	271.5	<0.001	Significant
Education	1.789	0.172	Non-Significant

Table 4. Entrepreneurial attribute scores and rankings across the makhana farmers

S.No.	Entrepreneurial attributes	Mean Score	Rank
1	Production orientation	22.86	I
2	Marketing orientation	22.16	II
3	Management orientation	21.83	III
4	Risk-taking ability	17.8	IV
5	Achievement motivation	15.8	V

these, production orientation received the highest average score (22.86), securing the top rank, indicating farmers' strong focus on increasing yield and optimising cultivation practices. Marketing orientation (22.16) and management orientation (21.83) followed as the second and third highest-ranked attributes, respectively. These results suggest that farmers are relatively proactive in accessing markets and organising farm operations efficiently. On the other hand, attributes such as risk-taking ability (17.80), achievement motivation (15.80), and innovativeness (15.11) were ranked lower, indicating a more cautious or traditional mindset in entrepreneurial behaviour.

DISCUSSION

This methodological approach yielded three distinct clusters based on empirical differences in key variables: landholding size, annual income, makhana income, and entrepreneurial attributes. The clustering technique facilitated the delineation of distinct farmer groups, thereby moving beyond descriptive profiling to generate actionable classification. Results from Tables 1 and 2 confirmed significant variation across clusters in landholding ($p < 0.001$), annual income ($p < 0.001$), and makhana income ($p < 0.001$), but not in educational attainment ($p = 0.172$). Levene's test (Table 3) further validated heterogeneity of variances for landholding and income variables, reinforcing the robustness of the cluster distinctions.

Larger landholdings and higher income were often associated with increased adoption of agricultural technologies and practices. For instance, Wang et al., (2023) noted that professional farmers with high education levels, large-scale farmland operations, and high levels of agricultural mechanization participated in digital finance, which played a more significant role in promoting their total household income. This suggests that farmers with larger landholdings may have better access to financial resources and technology. Interestingly, the cluster's low education levels contrast with the general trend observed. Aman et al., (2024) indicated that "education alone does not have a noticeable impact, signifying that specialised training can be more effective in improving adoption rates among small farmers with limited formal education" (Aman et al., 2024). This implies that formal education may not always be a determining factor in agricultural success. The older age and larger family size of the cluster align with some observations. Kibona & Yuejie (2021) mentioned that the average age of the interviewees was 53.73 years with a family size of 13.11. This suggests that older farmers with larger families are common in certain agricultural contexts. Extension efforts could involve capacity-building workshops, subsidies for micro-irrigation systems, and community-based water management models to improve the adoption of these practices (Kumar et al., 2020; Pundir et al., 2025).

The production orientation of the respondents, measured through entrepreneurial attributes, attained the highest mean score of 22.86, securing the first rank, followed by marketing orientation, which recorded a mean score of 22.16 and ranked second. Management orientation with a mean score of 21.83 ranked 3rd. Finally, risk-taking ability ranked 4th with a mean score of 17.80. The lower innovativeness score reflects limited engagement with novel practices or technologies, which may hinder productivity growth and adaptation to market changes. These findings align with the cluster-based analysis, where Cluster 2 exhibited higher entrepreneurial scores across most dimensions. The results underscore the need for tailored interventions–enhancing innovation training and achievement-oriented incentives, particularly for clusters with lower entrepreneurial indices. Strengthening entrepreneurial capabilities, especially in innovation and risk-taking, could significantly improve resilience and profitability among makhana farmers, thereby supporting more dynamic agricultural entrepreneurship in Bihar's aquatic crop sector. These results were consistent with previous studies conducted by Chandrashekhar (2010); Parthiban et al., (2018); Afros et al., (2021) & Afros et al., (2022) where the motivation for entrepreneurs had a higher utility. The insights gained from this research can be invaluable in shaping future training programs to better align with the specific needs and expectations of agripreneurs, also aligned with Kumari et al., (2024).

CONCLUSION

The study classified 120 makhana farmers in Bihar into three distinct clusters based on landholding, income, and entrepreneurial traits, achieving its objective to reveal socio-economic diversity. Cluster II, with the highest innovativeness and achievement motivation, shows strong potential for adopting new technologies and market linkages. Cluster III, despite moderate resources, had lower entrepreneurial engagement, indicating a need for capacity-building and input support. Cluster I, though economically well-off, exhibited low education and entrepreneurship levels, highlighting the need for customised extension strategies. The findings contribute to academic knowledge by demonstrating the utility of cluster analysis in farmer classification. For practitioners and policymakers, the study offers actionable insights for the precise targeting of extension programs and efficient resource use. Future research could examine the long-term impacts of cluster-specific interventions and include socio-cultural factors for a comprehensive understanding of makhana farmers' adoption behaviour, thereby supporting sustainable agricultural development in flood-prone regions.

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Research Article

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Factors Influencing Farming Practices towards Nutrition Sensitive Agriculture in Southern Odisha

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HIGHLIGHTS

- The study indicates the critical role of nutrition sensitive agriculture in preventing malnutrition.
- There is a need of clear communication and alignment between policy makers and farmers.
- The respondents can change their attitude towards nutrition sensitive agriculture through proper education and intervention.

ARTICLE INFO

Keywords: Agriculture, Attitude, Food security, Nutrition, Perception.

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ABSTRACT

In order to alleviate food and nutrition insecurity, nutrition-sensitive agriculture places a strong emphasis on integrating agricultural interventions with nutrition goals. Understanding how attitudes and perception influences the nutrition practices and dietary choices is crucial for effective nutrition sensitive agriculture. The study explores how household practices influence the nutritional outcomes and factors affecting nutrition sensitive agricultural interventions aimed at improving people's dietary patterns**.** This method seeks to enhance the quality and variety of diets in addition to increasing food production by acknowledging the connections between nutrition, agriculture, and health. Though there are varying perspectives and obstacles to overcome, nutrition-sensitive agriculture is generally seen favorably, with many acknowledging its potential to improve food systems. The present study was conducted in Gajapati and Rayagada districts of Odisha in 2024. Three blocks were selected from each district, totaling six blocks randomly, total of 20 respondents from each block selected by simple random sampling technique to form a total sample size were 120. Majority of respondents (53%) were having less favourable perception towards Nutrition Sensitive Agriculture with moderate (59%) attitude towards nutrition sensitive agriculture.

INTRODUCTION

In order to meet the global nutrition targets, governments, donor agencies, and development organizations nutrition-sensitive agriculture places a strong emphasis. Although nutrition-specific interventions are important, they are not enough to achieve these goals (Bhutta et al., 2013; WHO, 2024). Nutritious food is essential for health emphasizing the importance of teaching rural households about the need of nutrients for growth and wellbeing (Kumbhare et al., 2023). By addressing concerns of family food security, dietary quality, income, women's empowerment, and global food availability, agriculture has a major impact on nutrition (Black et al., 2013). However, contributions from other sectors are equally critical.

Food availability, often measured through local food grain production, is central to food security, while food stability ensures consistent household access to adequate food (Jatav & Mubeena, 2023). Policies that support nutrition-sensitive agriculture should increase awareness regarding the health benefits of millets, stimulate the variety of recipes, and guarantee their availability through public distribution systems (Amrutha et al., 2024). Targeted nutritional

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education programs for low-income farm women improve dietary practices and household food security (Dominic et al., 2023). Studies reveal gender disparities in diets, with males generally consuming more diverse and balanced food compared to females, who often have less nutritious diets (Vij & Mann, 2022). A bottom-up approach focusing on community and household levels provides better insights into food and nutritional security (Jairu et al., 2023).

In India, food security is evaluated through nutrient absorption, availability, and access. While cereal production is adequate, shortages in oilseeds and pulses persist. A multidisciplinary strategy is needed to address food insecurity, encompassing education, women's empowerment, safe water, sanitation, and nutritional diversity. Despite rising incomes and protective measures, food insecurity and malnutrition remain significant challenges, necessitating effective, people-focused policies (Dev & Sharma, 2010). Awareness programmes for education and outreach are essential for promoting awareness of sustainable farming practices and their implementation, which improve nutrition and food security (Mishra et al., 2024). The 66th National Sample Survey (2009–10) highlighted socio economic and regional disparities in rural food consumption. The bottom 20 per cent of households consumed less cereal (11.73 kg) than the national average, while wealthier groups ate more fruits, vegetables, milk, and pulses, with reduced cereal intake. Agricultural self-employed households consumed more milk and cereals. Religious preferences influenced cereal choices, such as Christians favouring rice and Jains and Sikhs preferring wheat. Larger families and marginalized groups, like scheduled castes and tribes, had less diverse diets, increasing malnutrition risks, with agro-climatic zones further shaping consumption patterns (Gupta & Mishra, 2014).

Food security depends on physical and economic access, with income, market access, and affordability playing key roles. Adequate food supply alone is insufficient; effective distribution networks are essential (Keding et al., 2013). In Karnataka's Vijayapura district, dietary diversity correlated with household size, education, income, and production diversity. Nutrition-sensitive policies, infrastructure investments, and modern technologies are crucial for improving diets, especially for children (Pingali & Sunder, 2017). Progress is hindered by barriers like illiteracy, limited training, and weak KVK-NGO interactions (Dagar & Upadhyaya, 2022).

METHODOLOGY

The research was conducted in the Gajapati and Rayagada districts of Odisha, using a simple random sampling method with a total sample size of 120 participants. Gajapati has 7 administrative blocks. In the Gajapati district, three blocks–R. Udayagiri, Gumma, and Rayagada were selected by simple random sampling out of the seven blocks based on nutritional vulnerability. Subsequently, from Sabarapalli, Phatachanchara, and Parimala villages from R. Udayagiri block; Tibi Singh, Linga, and Munising from Gumma; and Kaithapadar, Dambapur, and Hirapur from Rayagada**.** Twenty respondents sampled from each block, resulting in a total of 60 respondents for the district. Similarly, in the Rayagada district, three blocks–Rayagada, Muniguda, and Gunupur–were selected randomly. Three villages fromPitamahal, Manikajhola, and Bishnuguda from Rayagada; Sakata, Munikhola, and Kaliarpeta from Muniguda; and Regada, Laba, and Sirijholi from Gunupur were selected randomly resulting a total 60 respondents in Rayagada district. So the total number of respondents under study is 120.

Data collection was conducted through personal interviews with farmers using a structured interview schedule. Prior to this a pilot study was conducted for discussing with progressive farmers, extension officers and financial institution officials. This information helped for selecting and finalizing the variables to prepare interview schedule. Various scales and scoring methods developed by previous researchers were employed with slight modifications. Perception and attitude toward nutrition-sensitive agriculture were considered the dependent variables. Independent variables were measured using 3-point, 4-point, and 5-point scales developed by different researchers, while dependent variables were assessed using a 3-point scale (Agree = 1, Disagree = 2, Neither Agree nor Disagree = 3), as developed by Junuthula et al., (2022).

In total, the study included 19 independent variables and 4 dependent variables tailored for farm families. Data collected were categorized, organized, and analyzed to meet the study's objectives. Mean, standard deviation, frequency, percentage, correlation coefficient, regression analysis and other statistical methods were used using the OPSTAT (Operational Statistics) online open-access software. A perception and attitude index, calculated using a specified formula, was utilized to examine the factors influencing farming practices toward nutrition-sensitive agriculture in southern Odisha. The analysis focused on respondents' perceptions and attitudes toward promotional activities, such as government policies or schemes, training programs, workshops, support from NGOs or FPOs, and household nutrition practices.

RESULTS

Cultural beliefs, socioeconomic status, and level of education in the study field are some of the variables that influence how people perceive nutrition-sensitive agriculture. It is observed that in Table 1 majority of (74.1%) respondents choosing a diet with a lot of fresh fruits and vegetables in good for one's health, eating

Table 1. Item-wise Perception of respondents towards Nutrition Sensitive Agriculture

Statements	Percentage
Choosing a diet with a lot of fresh fruits and vegetables is good for one's health	74.11
Eating variety of foods is good for one's health	60.00
Choosing a diet with lots of staple foods (rice, rice products, wheat) is not good for one's health	45.00
Consuming animal products (Fish, egg, meat) daily is good for one's health	54.12
Consuming dairy products and nuts is good for one's health	50.00
Refined grain (rice, wheat flour) contains more vitamins than unrefined grains	41.72
Advertisement are very reliable source of getting nutritional information	54.13

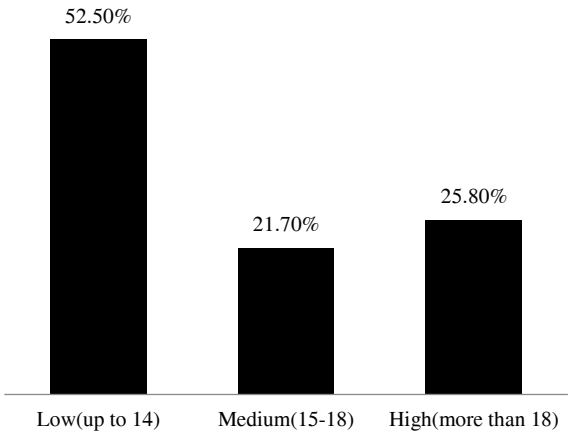

Figure 1. Overall Perception towards Nutrition sensitive agriculture

Table 2. Attitude towards Nutrition sensitive agriculture

Statements	Percentage
Do you want to know Nutrition Sensitive Agriculture	29.16
Have you attended any training program	38.33
Have you thought Crop diversification is required	43.33
Is the farmers and rural people are adopting nutrition sensitive practices	28.33
Have you thought the integration of nutrition education and awareness campaign is required	34.16
Do you think policy makers, extension personnel should promote and support Nutrition Sensitive Agriculture	48.33
Your general attitude towards Nutrition Sensitive Agriculture	35.00

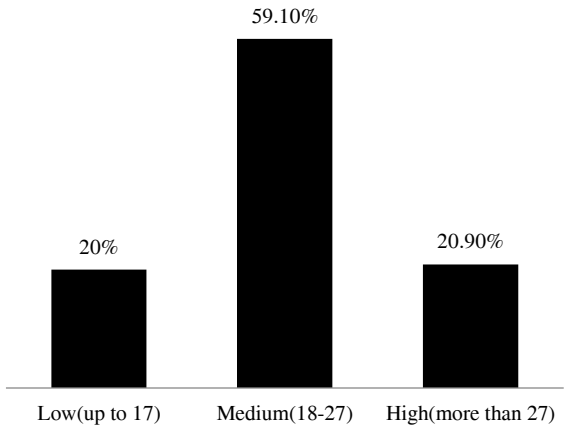

Figure 2. Overall Attitude towards Nutrition sensitive agriculture

variety of foods is good for one's health (60%), choosing a diet with lots of staple foods(rice, rice products, wheat) is not good for one's health (45%), consuming animal products (Fish, egg, meat) daily is good for one's health (54.1%), consuming dairy products and nuts is good for one's health (50%), refined grain (rice, wheat flour) contains more vitamins than unrefined grains (41.7%), Advertisement are very reliable source of getting nutritional information (54.1%). From figure-1 it is observed that majority of respondents were having low level (52.5%) of perception, followed by high level (25.8%) and moderate level (23.7%) of perception towards Nutrition Sensitive Agriculture.

It was observed that majority of respondents were having moderate to low level of attitude towards nutrition sensitive agriculture. In Table 2 do you want to know nutrition sensitive agriculture? (59.1%), have you attended any training program? (28.3%), have you thought Crop diversification is required? (37.5%), Is the farmers and rural people are adopting nutrition sensitive practices? (40%), Have you thought the integration of nutrition education and awareness campaign is required? (45%), do you think policy makers, extension personnel should promote and support nutrition sensitive agriculture? (36.7%), your general attitude towards nutrition sensitive agriculture? (43.4%). In Figure 2 majority of (59%) of respondents were having moderate level of attitude, followed by low level (21%) and high level (20%) of attitude towards Nutrition Sensitive Agriculture.

In Table 3, majority of (57.5%) respondents were having low level of household nutrition practice, followed by medium level (22.5%) and high level (20%) of household nutrition practices towards Nutrition Sensitive Agriculture.

Relationship of Independent variables with perception, attitude and house-hold nutrition practices about nutrition sensitive agriculture

The link between the scores of the selected independent variables and the degree of perception, attitude, and household nutrition practices was examined using the null hypothesis and the

Table 3. House-hold nutrition practice towards Nutrition sensitive agriculture

House-hold nutrition practice	Percentage
Who has control over the nutrition in your family	28.33
Who purchase and collect food	26.66
Food preference given by	20.00
Who prepare meal	22.51
Who manage water source	24.16
How many meals per day do you eat	26.66
If you skip meals what meal(s) do you usually skip	18.33
Purpose of skip any meal	22.51
Portion size of your meals	29.16
Take any Multivitamin/ food supplement	23.33
How often do you snack	22.51
Preferred meal choice	23.33

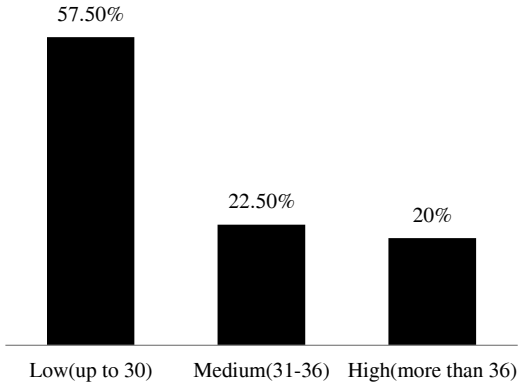

Figure 3. Overall House-hold nutrition practice towards Nutrition sensitive agriculture

Table 4. Relationship of independent variables with perception and attitude about nutrition sensitive agriculture

Independent Variable	Correlation coefficient of Perception	Correlation coefficient of Attitude
Age	0.042^{NS}	0.008^{NS}
Gender	0.202*	-0.069^{NS}
Caste	-0.130^{NS}	-0.302**
Types of farmer	0.337**	0.456**
Education	0.390**	0.505**
Family Size	-0.066^{NS}	-0.085^{NS}
Nutrition deficiency	-0.262**	-0.243**
Nutrition status	0.224*	0.298**
Housing Condition	0.347**	0.451**
Crop Calendar	0.060^{NS}	0.112^{NS}
Meals taken yesterday	0.301**	0.337**
Food source	0.109^{NS}	0.217*
Preference of Food	0.280**	0.412**
Primary source of Income	-0.279**	-0.108^{NS}
Annual income	0.305**	0.400**
Asset Possession	0.439**	0.598**
Outside contact	0.498**	0.665**
Information seeking Behaviour	0.386**	0.520**
Extension media contact	0.552**	0.672**

** = 1% level of significance; * = 5% level of significance

Table 5. Regression analysis with perception about nutrition sensitive agriculture

Independent Variable	Coefficients	Standard Error	t Value	Significance
Profile variable				
Age	-0.086	0.046	-1.860	0.065
Gender	-1.217	0.894	-1.361	0.176
Caste	-0.388	0.529	-0.733	0.465
Types of farmer	0.129	0.681	0.190	0.850
Education	1.053	0.663	1.589	0.115
Family Size	0.227	0.273	0.833	0.407
Nutrition deficiency	-0.383	0.282	-1.359	0.177
Nutrition status	0.524	0.634	0.826	0.410
Household-dynamics				
Crop Calendar	0.021	0.020	1.094	0.276
Meals taken yesterday	-0.023	0.212	-0.106	0.916
Food source	-0.141	0.881	-0.161	0.873
Preference of food group	0.049	0.158	0.311	0.756
Socio-economic variables				
Housing Condition	0.222	0.190	1.164	0.247
Primary source of Income	-0.474	0.153	-3.099	0.002
Annual income	0.466	0.776	0.600	0.549
Asset Possession	0.175	0.140	1.255	0.212
Social variables				
Outside contact	0.355	0.266	1.336	0.184
Information seeking Behaviour	-0.192	0.188	-1.023	0.308
Extension media contact for advice	0.270	0.141	1.921	0.057
Constant	15.680			
R^2	0.5052			

empirical hypothesis. The correlation coefficient (r) was calculated and the result was shown in Table 4. Table 4 describes that perception, attitude and house-hold nutrition practices about nutrition sensitive agriculture is highly significant and positively correlated with types of farmer, education, housing condition, meals taken yesterday, preference of food, primary source of income, annual income, asset possession, outside contact, information seeking behaviour, extension media contact at 1 percent significant level and perception is positively significant with gender, nutrition status, primary source of Income and attitude is positively significant with food source at 5 percent significant level. But nutrition deficiency is highly significant and negatively correlate with perception 5 per cent significant level and caste, nutrition deficiency is highly significant and negatively correlate with attitude at 5 per cent significant level and gender, caste is negatively significant with house-hold nutrition practices at 5 per cent significant level and nutrition deficiency and primary source of income is highly significant and negatively correlate with house-hold nutrition practices at 1 percent significant level.

Factors influencing farming practices towards Nutrition Sensitive Agriculture

The multiple regressions (Table 6) could explain only 75.47 percentage of the variability in influencing the factors influencing

Table 6. Regression analysis with attitude about nutrition sensitive agriculture

Independent Variable	Coefficients	Standard Error	t Value	Significance
Profile variables				
Age	-0.092	0.043	-2.118	0.036
Gender	0.757	0.841	0.900	0.370
Caste	1.022	2.548	0.401	0.689
Types of farmer	-0.115	0.640	-0.180	0.858
Education	1.641	0.623	2.632	0.010
Family Size	0.454	0.257	1.770	0.079
Nutrition deficiency	-0.126	0.265	-0.475	0.636
Nutrition status	1.265	0.597	2.121	0.036
Household-dynamics				
Crop Calendar	0.045	0.018	2.474	0.015
Meals taken yesterday	-0.007	0.199	-0.034	0.973
Food source	0.094	0.829	0.114	0.910
Preference of food group	0.141	0.149	0.948	0.345
Socio-economic variables				
Housing Condition	0.383	0.179	2.138	0.035
Primary source of Income	-0.140	0.144	-0.976	0.331
Annual income	0.677	0.730	0.928	0.355
Asset Possession	0.403	0.131	3.069	0.003
Social variables				
Outside contact	0.700	0.250	2.795	0.006
Information seeking Behaviour	-0.177	0.177	-1.001	0.319
Extension media contact for advice	0.379	0.132	2.860	0.005
Constant	7.947			
R^2	0.7547			

farming practices towards Nutrition Sensitive Agriculture among 19 variables. The variables age, gender, caste, types of farmer, education, family size, nutrition deficiency, nutrition status, housing Condition, crop Calendar, Meal taken yesterday, food source, preference of food, primary source of income, annual income, asset possession, socio-economic variables, information seeking behaviour, outside contact, extension media contact are helpful in increasing the factors influencing farming practices towards Nutrition Sensitive Agriculture.

DISCUSSION

The data gathered from two districts to know the factors influencing farming practices towards nutrition sensitive agriculture Majority of respondents were having low level (52.5%) of perception, followed by high level (25.8%) and moderate level (23.7%) of perception towards Nutrition Sensitive Agriculture. Majority of (59%) of respondents were having moderate level of attitude, followed by low level (21%) and high level (20%) of attitude towards Nutrition Sensitive Agriculture. Majority of (57.5%) respondents were having low level of household nutrition practice, followed by medium level (22.5%) and followed by high level (20%) of household nutrition practices towards Nutrition Sensitive Agriculture. Many nutrition outcomes are improved when agricultural programs are packed with interventions that target a variety of direct and underlying determinants of nutrition, including income, food availability and access, micronutrient adequacy, gender equity, and knowledge, practices, and use of nutrition, health, and hygiene-related services. Possible interventions include promoting the production of nutrient-dense crops (leafy greens, pulses, and millet) in addition to basic cereals, concentrating policy on increasing the variety of household diets, and directing extension services towards women and children, who are more susceptible to malnutrition. Incorporating nutrition education into agricultural training modules includes teaching farmers about kitchen gardens and bio-fortified crops to improve household nutrition, teaching them about post-harvest handling, processing, and marketing of nutrient-dense foods, and using gender-sensitive approaches to design training that empowers women farmers and recognises their role in household food decisions. The study was carried out under certain limitations of time and resources available with researchers, covering only selected Gajapati and Rayagada districts. Some personal, nutritional status, economic, situational and psychological characteristics other than those included in this study might be affecting the accessibility, availability, and absorption of nutrition-sensitive interventions by farmers.

CONCLUSION

The Perception, Attitude, and Household Nutrition Practices Index revealed that 52.5 per cent had a low perception level, 59 per cent showed a moderate attitude level, and 57.5 per cent had low household nutrition practices. The results emphasize how crucial nutrition-sensitive agriculture in preventing malnutrition and its connection to farming practices, though interpretations of this concept may vary among farmers and policymakers. Greater funding and supportive legislation are required to promote nutrition-sensitive agriculture, with governments, international organizations, and NGOs playing critical roles in providing resources and technical support. Strategies such as crop diversity, increasing dietary diversity, and educating farmers about the nutritional value of various foods are essential to improve dietary habits and promote nutrient-rich farming practices for better nutrition outcomes. Farmers should be encouraged to cultivate crops high in nutrients such as fruits, vegetables, legumes and millet. Extension officials should provide farm advice along with nutrition messages.

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Development of a Standardised Scale to Measure Farmers' Attitude towards Indigenous Cattle Conservation: A Methodological Approach

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HIGHLIGHTS

- The 20 out of 36 attitude statements met selection criteria, showing their relevance towards indigenous cattle conservation.
- Both positive and negative statements were included as key dimensions of the scale.
- Cronbach's alpha value exceeded 0.80, indicating high internal consistency and thus testify the reliability of the scale

ARTICLE INFO

Keywords: Cronbach's alpha, Mean relevancy score, Native cattle, Relevancy weightage, Reliability, Spearman brown, Validity.

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ABSTRACT

The standardized scale was developed to measure farmers' attitudes towards the conservation of indigenous cattle in 2023 in the Bareilly district of Uttar Pradesh state. A total of 55 items were subjected to experts for relevancy testing, and finally, 36 items were selected for item analysis. These 36 items were presented to 42 respondents from other than the study area. The item analysis score was performed using Likert's rating technique of measurement, and t values were calculated for each item. Finally, 20 items were selected and were standardized by establishing their reliability (split-half method) and validity (content validity). The overall test reliability (using Spearman Brown formula), Cronbach's alpha value, and overall content validity index were 0.791, 0.829, and 0.930, respectively. Thus, the reliability and validity of the current scale indicate its consistency and precision of the results. The developed scale will help the researchers in assessing the attitude of farmers towards the conservation of indigenous cattle within a defined target population. Additionally, it will facilitate the development of evidence-based extension strategies and programs designed to enhance conservation efforts and sustainable livestock management.

INTRODUCTION

Due to population growth and the increasing demand for milk and dairy products, livestock production systems in developing countries like India are rapidly evolving. This growing pressure on production systems worldwide necessitates alternative strategies, such as crossbreeding, to enhance milk yield and ensure sustainability. Eventually, many indigenous breeds have been displaced by intensively selected breeds and their high-input input-high output production systems. However, many indigenous breeds have survived, especially in areas where high-input, high-output systems were not established for economic, cultural, or environmental reasons (Sreelakshmi & George, 2019). Indigenous cattle are renowned for their amazing capacity for endurance under hot tropical climates, resilience to tropical diseases and low maintenance cost. The various indigenous breeds of agricultural animals are mostly the consequence of evolutionary processes (Rai et al., 2023). The total indigenous cattle population of India has declined by 6 per cent in 2019, when compared to the previous census of 2012. However, the pace of this decline is much lesser

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compared to previous census (2007-12) which was about 9 per cent (20th Livestock census, 2019). Crossbreeding in India has primarily aimed at improving milk production, disregarding the genetic potential of indigenous breeds, while demographic pressures have led to a decline in native cattle populations due to the growing demand for animal protein through milk production (Sarang et al., 2024).

Conserving the genetic diversity of indigenous cattle breeds is of utmost importance, given their varying conservation status. The loss of cattle genetic diversity has been found to be augmented by intensification of production systems, lack of characterization of indigenous breeds adapted to a particular agro-ecological zone, and also inappropriate breed replacement by crossbreeding with high producing breeds to improve productivity (Mukesh & Sodhi, 2013). To meet the need of future generations, concerted efforts are needed to conserve and grow indigenous cattle. In recent years, indigenous cattle breeds have gained scientific and policy attention for their adaptability, genetic diversity and contributions to sustainable livestock production, while also playing a significant role in maintaining biodiversity, supporting ecosystem services, preserving cultural and socio-economic values in traditional farming systems. Attitude towards conservation is more easily defined theoretically than observed in reality because it includes a wide variety of dimensions (Winter et al*.,* 2005). The attitude behaviour relationship in the context of farmers' conservation behaviour and attitudes was found to be a prime predictor of farmer conservation behaviour (Padel, 2001). Considering the aforementioned factors, the present study was conducted with the aim of developing and validating a standardized scale to measure farmers' attitudes toward the conservation of indigenous cattle.

METHODOLOGY

Attitudes toward conserving specific cattle breeds or vegetation comprise multiple dimensions. These attitudes can be measured directly by asking respondents to report their beliefs or evaluations, or indirectly by studying responses believed to correlate with attitudes (Bohner & Wanke, 2002). The study was conducted in the Bareilly district of Uttar Pradesh state of India. In the current study, attitude was defined as the positive or negative predisposition of farmers towards indigenous cattle rearing, serving as a significant factor influencing their behaviour in conserving these cattle. A scale to assess respondents' attitudes towards indigenous cattle rearing was developed using Likert's summated rating method (Likert, 1932). A total of 70 statements were tentatively selected, comprising 45 positive and 25 negative statements, ensuring their relevance to the study area. The collected statements were carefully refined according to the 14 informal criteria suggested by Edwards (1957). As a result, 55 statements were retained out of the initial 70.- After that, the test of relevancy was carried out on the remaining 55 selected statements, in which the statements were sent to 42 experts for their expert evaluation of the statements' relevancy (Boora et al., 2024; Panigarhi et al., 2024; Vavilala et al., 2024). The responses to the statements were collected through personal interviews, email, and a Google form. The experts were scientists/ professors from ICAR institutions and veterinary and agricultural universities. The responses were collected on a three-point continuum, *viz.,* Most Relevant, Relevant, and least Relevant, with scores 3, 2, and 1, respectively. A total of 36 statements were selected as relevant based on the rating of 30 judges who responded, and these items were used further for the critical ratio or t-value estimation. Finally, statements with a t value of 1.75 or higher were finally selected for the scale. The split-half method assessed the reliability of this scale, while the content validity test evaluated validity.

RESULTS

The data presented in Table 1 comprises 36 selected items related to the conservation of indigenous cattle within the specific context. The selection of relevant statements for the scale was conducted after the relevancy test.

Relevancy test

The relevancy judgements along with valuable suggestions were received from 30 judges in stipulated time of one month. In order to ensure the field applicability of the statements, relevancy scores were also obtained from 20 field veterinarians in Bareilly district. The responses obtained from both the group of judges to each statement were combined together. The Relevancy Weightage (RW) and Mean Relevancy Score (MRS) for each selected indicator were calculated individually using the following formula:

$$Relevancy\ Weightage\ (RW) = \frac{(Most\ relevant \times 3) + (Relevant \times 2) + (Least\ relevant \times 1)}{Maximum\ possible\ score}$$

$$Mean\ Relevancy\ Score\ (MRS) = \frac{(Most\ relevant \times 3) + (Relevant \times 2) + (Least\ relevant \times 1)}{Number\ of\ judges}$$

$$Overall\ Mean\ Relevancy\ Score\ (OMRS) = \frac{Sum\ of\ weightage\ of\ all\ indicators}{Total\ Number\ of\ judges \times Total\ Number\ of\ statements}$$

Item analysis

Item analysis is an essential process in developing a valid and reliable scale using Likert's rating technique of measurement. It is conducted to identify items that contribute to an internally consistent scale while eliminating those that do not (Spector, 1992). All statements having Relevancy Weightage (RW) value of more than 0.75 and Mean Relevancy Score (MRS) value of more than or equal to Overall Mean Relevancy Score (OMRS) i.e., 2.24 were considered for item analysis. As a result a total of 36 statements were selected for evaluation of critical ratio ('t'- value). All the 36 statements which were selected after expert relevancy test were administered to a random sample of 48 cattle farmers who reared indigenous cattle in the non-sample area of Bishnupur district of Manipur state. These cattle farmers were requested to express their degree of favourableness or unfavourableness towards each statement on five point continuum from 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree' with score of 5, 4, 3, 2 and 1 respectively for positive statements and the scoring pattern was reverse for negative statements. The overall score for each respondent was determined by summing up the scores across all items. Based on total individual scores, the respondents were systematically arranged in descending order. For determining the 't' value, 25 per cent of the respondents with highest scores and 25 per cent with lowest scores i.e., 12 respondents each from these two groups were taken for item analysis. Item analysis was

Table 1. Relevancy Weightage (RW), Mean Relevancy Score (MRS), t-value of the attitude statements, selected statements with their respective "I-CVI"

S. No.	Attitude Statements	RW	MRS	t-value	Agree-ment	I-CVI
1	Since native cattle are climatically adapted, they do not require particular care (-)	0.76	2.29	2.42*	5	1
2	I believe that the native cattle are worth keeping since they have good temperament (+)	0.85	2.55	4.13*	4	0.80
3	Native cattle are mainly utilized for draught purposes	0.75	2.26	1.53	-	-
4	I prefer to keep native cattle since they have better disease resistance than exotic cattle (+)	0.79	2.38	2.43*	5	1
5	The daily income generated from indigenous cattle farming is comparatively lower than that from crossbred cattle farming (-)	0.75	2.26	2.43*	5	1
6	I feel that local people should engage in a more active role, only then conservation of native cattle will be successful	0.85	2.55	1.25	-	-
7	Native cattle have better milk quality, value and taste than exotic cattle	0.90	2.71	1.18	-	-
8	Only socio-economically weaker sections of the society rear the indigenous cattle (-)	0.81	2.43	5.11*	4	0.80
9	It is necessary to establish breeding facilities exclusively for native cattle	0.86	2.57	1.62	-	-
10	Native cattle are traditionally reared from past generation considering their cultural and aesthetic value (+)	0.80	2.40	2.65*	5	1
11	The younger generation shows a lack of interest in managing and rearing indigenous cattle (-)	0.80	2.40	2.40*	5	1
12	Indigenous cattle exhibit efficient grazing behaviour throughout all seasons	0.77	2.31	1.27	-	-
13	Indigenous cattle have superior resilience and survivability compared to crossbred cattle during natural disasters (+)	0.77	2.31	1.95*	5	1
14	There is a need to review respective state breeding policies so as to prioritize their conservation efforts	0.91	2.74	1.67	-	-
15	I am skeptical about the potential benefits associated with native cattle farming	0.81	2.43	1.21	-	-
16	The farmyard manure produced by indigenous cattle is more beneficial for agricultural purposes	0.83	2.48	1.18	-	-
17	Indigenous cattle can thrive well in basic or traditional (kaccha) housing structures (+)	0.80	2.40	4.83*	4	0.80
18	The slaughter of indigenous cattle (cows and bulls) for meat should be actively discouraged (+)	0.83	2.50	1.95*	5	1
19	In my opinion, native cattle require relatively minimum maintenance and care	0.75	2.26	1.21	-	-
20	I do not want to keep native cattle as they produce less milk output (-)	0.79	2.36	2.72*	5	1
21	Keeping native cattle will not be beneficial in the long run (-)	0.82	2.45	2.22*	5	1
22	I keep native cattle because they are less expensive to buy than crossbred cattle (+)	0.87	2.62	3.45*	5	1
23	There should be collaboration between government and research institutions in order to effectively maintain local cattle population	0.90	2.71	1.54	-	-
24	Provision of Artificial Insemination exclusively for native cattle should be established	0.87	2.60	0.98	-	-
25	The excreta (dung, urine) of native cattle have lot of medicinal properties than crossbred or exotic cattle (+)	0.80	2.40	1.95*	4	0.80
26	I think banks will not support in providing loans to keep native cattle (-)	0.83	2.50	2.75*	4	0.80
27	Running native cattle farm are not as profitable as crossbreed or exotic cattle farms (-)	0.89	2.67	3.20*	4	0.80
28	I believe it's not possible to bring rearing of native cattle up to the commercial business level	0.76	2.29	1.67	-	-
29	Native cattle are an indispensible part of our culture and should be conserved	0.80	2.40	1.27	-	-
30	Preference for using milk from native cattle over that from crossbreed or exotic cattle for religious purposes	0.82	2.45	1.25	-	-
31	Indigenous cattle demonstrate a higher efficiency in utilizing agricultural by-products as feed resources	0.79	2.38	1.35	-	-
32	The overall lifetime productivity of indigenous cattle is lower compared to that of crossbred cattle (-)	0.76	2.29	3.24*	5	1
33	The native cattle's dung can be used for fuel, manure and building materials (+)	0.79	2.38	2.57*	5	1
34	The selection of a superior breeding bull is necessary for maintaining pure germplasm in order to conserve native cattle (+)	0.88	2.64	2.65*	5	1
35	I prefer to expand my farming operations by increasing the population of native cattle on my farm	0.79	2.36	1.16	-	-
36	The market demand and commercial viability of indigenous cattle are relatively limited (-)	0.87	2.62	2.68*	4	0.80
	OMRS	2.24			S-CVI/Avg 0.93	
					Total agreement 13	

*Selected Statements, (+): Positive Statements, (-): Negative Statements, I-CVI= Item Level Content Validity Index, S-CVI= Scale-Content Validity Index

conducted based on the criteria established by these two groups. The 't' value, is a measure of how effectively a statement differentiates between high and low respondent groups for each item and was calculated using the formula provided by Edwards (1957).

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\Sigma(X_H - \bar{X}_H)^2 + \Sigma(X_L - \bar{X}_L)^2}{n(n-1)}}}$$

Where,

$\Sigma(X_H - \bar{X}_H)^2 = \Sigma(X_H)^2 - \frac{(\Sigma X_H)^2}{n}$ and $\Sigma(X_L - \bar{X}_L)^2 = \Sigma(X_L)^2 - \frac{(\Sigma X_L)^2}{n}$

$\bar{X}_H$ = Mean score of a given statement in high group

$\bar{X}_L$ = Mean score of a given statement in low group

$\Sigma(X_H)^2$ = Sum of squares of the individual score on a given statement for high group

$\Sigma(X_L)^2$ = Sum of squares of the individual score on a given statement for low group

ΣX_H = Summation of scores on given statement for high group

ΣX_L = Summation of scores on given statement for low group

n = Number of respondents in each criterion group

The critical ratio ('t'- value) of each statement was calculated for the remaining items and those items having t value equal to or, more than 1.75 were selected as this t-value significantly differentiated between high and low groups of items and those having t value <1.75 were discarded as per the rule suggested by Bird (1940). Based on the prescribed selection criteria, 20 statements were retained for the final scale, as they exhibited the highest discriminatory power, while items with low discrimination indices and lower validity were excluded. Consequently, the finalized attitude scale comprised 20 items, consisting of positive (10) and negative (10) statements for measuring the attitude towards the conservation of indigenous cattle. Both positive and negative statements were included in the final scale deliberately avoiding neutral statements, following the methodological recommendations of Edwards & Kilpatrick (1946).

Reliability of the scale

The reliability of a testing instrument refers to its capacity to yield consistent, stable, and precise measurement scores upon repeated administration using the same instrument. It helps in evaluating the homogeneity of items within the scale. In the present study, the split-half method was employed to assess the reliability of the scale by dividing the items into two subsets based on odd and even-numbered statements. The Pearson product-moment correlation coefficient between the scores of the two halves was calculated as 0.654, representing the split-half reliability of the scale. To adjust this coefficient for full-test reliability, the Spearman-Brown prophecy formula (1910) was applied as follows:

$$R = \frac{2r}{1+r} = \frac{2\times0.654}{1+0.654} = 0.791$$

Where, R= Reliability coefficient of the whole scale

r = Pearson correlation between two halves

In the present study, standardized Cronbach's alpha was also employed to enhance the stability and accuracy of reliability estimation, as calculated using the following formula:

$$\alpha_{standardized} = \left(\frac{K}{K-1}\right)\left(\frac{S_y^2 - \Sigma S_i^2}{S_y^2}\right) = \frac{20}{20-1}\left[\frac{103.92-21.82}{103.92}\right] = 0.829$$

Where, K is the number of items in scale,

S^2_y = Variance associated with total observed score,

S^2_i = Variance associated with individual item score.

The value of Cronbach's alpha is found to be 0.829.

Validity of the scale

The validity of the scale was established through content validity. As defined by Kerlinger (1987), content validity refers to the representativeness or sampling adequacy of the content, substance, subject matter, and topics covered by a measurement instrument. Various methods exist to quantify experts' agreement on content relevance, with this study adopting Lynn's (1986) widely accepted approach. To quantify content validity, the 20 selected statements ('t' value >1.75) were evaluated by six experts (professors). The number of experts was limited to six, as increasing the panel size reduces the likelihood of complete agreement. A four-point rating scale was employed, following Davis (1992), to eliminate a neutral or ambivalent midpoint: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant and 4 = highly relevant. The Content Validity Index for individual items (I-CVI) was calculated to assess their relevance to the underlying construct, and subsequently, the Scale Content Validity Index (S-CVI) was computed to determine the overall content validity of the scale and is calculated by taking the sum of the I-CVIs divided by the total number of items. S-CVI/Ave > 0.9 has excellent content validity. For the current test, the calculated value of S-CVI/Avg of all the test items was 0.930.

DISCUSSION

A methodological approach in developing an attitude scale of farmers towards the conservation of indigenous scale indicates the systematic procedures and techniques used to design, develop, and analyse to ensure the scale's reliability and validity. The current study discussed the collection of attitude statements or items related to various aspects of indigenous cattle rearing, including socio-cultural roles, feeding, breeding, housing, healthcare, management, religious significance, draught utility, milk quality, and conservation. Editing of the statements by following Edwards' criteria to finalize the items for its relevancy test is performed. A total of 55 items for the relevancy test and 36 items were selected by calculating the mean relevancy score ($\geq$2.24) and further for item analysis in the non-sampling area of our study. Computation of the critical value or t-value of each statement for the final selection of items having 20 items consisting of 10 positive and 10 negative items. Standardisation of the scale: The present scale was standardized by establishing its reliability and validity. Reliability was determined using the split-half method and Cronbach's alpha, while validity was ensured through content validity assessment. The overall test reliability was determined to be 0.791, and since the reliability coefficient exceeded 0.7, the scale was considered highly reliable. Similar findings were reported by Kavithaa et al., (2021) in their

development of a scale to measure farmers' attitudes towards Kangayam cattle rearing in southern Tamil Nadu. Their study obtained a reliability coefficient of 0.823, indicating high internal consistency and testifying to the scale's reliability. The Cronbach's alpha value was found to be 0.829, indicating that the standardized attitude scale exhibits good internal consistency. This finding aligns with Shitu et al., (2018); Gupta et al., (2022) Boora et al., (2024), who reported a similar Cronbach's alpha for standardized attitude scale, thereby confirming the reliability of such scales. With an overall content validity of the test items coming at 0.930, the attitude scale constructed is considered highly stable and valid. This finding is in line with the results of Verma et al., (2024), who conducted a content validation process to measure sheep farmers' attitudes toward scientific sheep husbandry. Their study reported a content validity index of 0.908 for the overall scale. Administration of the developed scale can be done using a five-point continuum–strongly agree, agree, undecided, disagree, and strongly disagree–scored as 5, 4, 3, 2, and 1, respectively, for positive statements and reverse scoring applied to negative statements. The attitude of farmers towards the conservation of indigenous cattle can be evaluated using the class interval method by determining the range, minimum, and maximum scores. The total attitude score of a respondent is obtained by summing the individual statement scores based on their responses.

CONCLUSION

The newly developed standardised scale exhibits strong reliability and validity with a rigorous methodological process, from comprehensive item generation to systematic item analysis. It effectively measures various aspects of indigenous cattle rearing, demonstrating clear scoring procedures and adaptability for use by researchers, extension personnel, and policymakers seeking to evaluate or enhance farmer engagement in indigenous cattle conservation. While limited by its regional focus and the need for larger, more diverse samples, the scale provides a valuable evidence-based framework for designing targeted conservation programs and guiding sustainable livestock management. Future refinements could incorporate wider cultural contexts and longitudinal assessments to capture evolving attitudes over time.

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Cornell-Based Insights: Analyzing Farmers' Attitudes towards Scientific Backyard Poultry Farming Using the Guttman Scale

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HIGHLIGHTS

- The article used the Cornell Technique of the Guttman Scale, that effectively captures the varying levels of attitude of farmers towards scientific backyard poultry farming.
- By applying the Guttman Scale's cumulative and hierarchical structure, a refined tool for assessing attitude, ensuring reflection of various dimensions, was constructed.
- The scale offers a reliable method for identifying key areas where interventions can improve farmers' practices, enhancing both productivity and sustainability in backyard poultry farming.

ARTICLE INFO

Keywords: Scientific backyard poultry farming, Scalogram, Guttman scale, Cornell technique, Cutting points.

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Informed consent of the participants

ABSTRACT

The study focused on developing a Guttman Scale using the Cornell technique of the scalogram approach to assess farmers' attitudes towards scientific backyard poultry farming. While the Likert-type summated rating scale is commonly used in social science research, this paper explained the application of the Guttman scale. Out of 70 items selected, 55 statements were analysed, with 42 retained after ensuring a reproducibility coefficient of 0.85 or higher. The final scale demonstrated a high reproducibility coefficient of 0.92, reflecting strong accuracy in measuring the attitude of farmers towards scientific poultry farming. The scale's reliability and validity were confirmed through the split-half method, Cronbach's alpha, and content validity assessments. The final scale can be administered using a five-point continuum, ranging from highly unfavourable to highly favourable. This tool offers a valuable platform for assessing farmers' attitudes towards scientific backyard poultry farming. Following the scalogram approach, this cumulative scale will also serve as a useful reference for researchers in the social sciences seeking to develop similar measurement tools.

INTRODUCTION

Backyard poultry enterprise is especially beneficial for landless or economically disadvantaged families due to its low initial investment and high returns (Chakrabarti et al., 2014). Importantly, the sector aligns closely with the government's vision of doubling farmers' income by offering an additional and reliable source of earnings. Landes et al., (2004) reported that around 15 per cent of India's total poultry output comes from backyard systems, highlighting its significant contribution to rural livelihoods. As part of India's broader rural poultry production system, it complements other agricultural activities and strengthens household resilience against economic shocks (Sarwar et al., 2015; Weyuma et al., 2015). Barua & Yoshimura (1997) noted that poultry farming has become a routine practice in villages, creating a sustainable habit of income generation. Together with livestock farming, the poultry sector makes substantial contributions to India's economy (Nath et al., 2012), providing a pathway for small farmers to enhance their

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economic prospects. Furthermore, Mehta et al., (2003) observed that while crop production grows at a modest rate of 1.5–2 per cent annually, the poultry sector, including backyard systems, is growing at a much faster pace of 8–10% per year.

Despite its potential, the adoption of scientific practices in backyard poultry farming remains limited. Understanding farmers' attitudes towards these practices is critical for designing effective extension interventions. This study aims to create and validate a specialized scale for assessing the attitude of farmers toward scientific backyard poultry farming. Various scaling techniques are used for developing the scales on different aspects. The Likert scale, a widely used tool, is often affected by central tendency bias, where respondents may refrain from selecting extreme options, resulting in distorted outcomes. It can also be susceptible to acquiescence bias, where individuals have a tendency to agree with statements, regardless of their actual opinions. In addition, the Thurstone scale, while more sophisticated in its approach by presenting statements and asking respondents to evaluate them on a scale of agreement, can be complex to develop and administer. It also requires a substantial amount of preliminary work to ensure the scale is valid and reliable. In contrast, the Guttman scale introduced by Louis Guttman in 1944, takes a different approach by ensuring that if a respondent agrees with a specific statement, they will also agree with all previous statements in a sequential and cumulative order. The author created a scalogram analysis for tackling the issue of scaling public opinion and attitudes during the war to support research on the morale and associated facets of the US Army. Similar to other scales, it consists of a list of assertions with checkboxes for items that the respondent agrees or disagrees with. This scale's unique characteristic is the way its statements build up to a cumulative series. Since it was initially created at Cornell for instructional purposes, it was referred as the Cornell technique for scalogram analysis in order to differentiate it from a number of competing tools. Guttman scales are advantageous because a single response can be used to predict responses to all items on the scale; therefore, the Guttman scale is deterministic, items are "implicational" or "scalable," which defines them. This hierarchical method minimizes some of the biases associated with Likert and Thurstone scales and can provide a more nuanced understanding of scale.

METHODOLOGY

In the present study, construct was assessed as attitude of farmers towards scientific backyard poultry farming under major identified dimensions (construct) as livelihood aspects, nutritional aspects, income aspects, social aspects, technical and management aspects. A tentative list of 70 statements was enlisted keeping in view the suitability of statements to the study area based on review of literature, consultation with the CARI scientists and experts. The statements collected were cautiously edited by following the 14 informal criteria suggested by Edwards (1948). Thus, a total of 55 statements were taken out of 70 statements. When utilizing the Cornell technique of the Guttman scale, item analysis is a crucial step in creating a valid and trustworthy scale. The purpose of item analysis is to identify and eliminate items that do not form an internally consistent scale (Spector, 1997). We assumed that each statement is to have only two response categories such as agree and disagree, we assigned scores of 1 and 0 to the two response categories respectively. The statements were then administered to 30 experts in the field of veterinary sciences. Respondents were asked to respond to each statement in terms of their agreement or disagreement with it. Score was obtained for each respondent t by summing the scores assigned to the response categories being selected. Respondents were then arranged in rank order of their scores from high to low score. Using the Cornell technique, a table was constructed with one column for each response categories for each statement and one row for each respondent for 55 statements with two possible responses to each statement for 30 respondents. This would be a mean table with 110 columns and 30 rows. Starting with the respondent having highest score, the responses of each respondent to each statement were recorded by placing a cross mark in the appropriate cell of Table 1. On completion, the table provides a record of all available data. One can easily approximate the response of each item based solely on an individual's rank in the hierarchy in the Guttman scale. Since perfect reproducibility is not to be expected in practice, it becomes a matter of some importance to measure the degree of reproducibility present for any given set of responses to attitude statement. This is accomplished by setting cutting points for the response categories of each statement. Cutting point marks that place in the rank order of the respondent, where the most common response separates from one category to the other. Guttman offers two rules to be used in locating cutting points. The first is that the cutting point should be located so as to minimize error. The second is that no category should have more errors in it, than non-errors. For each statement, cutting points were placed, and errors were calculated for each of the two categories of 42 statements based on the coefficient of reproducibility e" 0.85. The sum of the errors for each category of overall statements as 97 and a total of (42) (30) = 1260 responses were calculated. The proportion of error is therefore 97/1260= 0.07, subtracting this value from unity gives us 1-0.07=0.92, Guttman called this value as coefficient of reproducibility. It indicated the 92 per cent accuracy with which 1260 responses to the 42 statements can be reproduced from the total scores.

$$CR = 1 - \frac{\text{Number of errors}}{\text{Total responses}}$$

Where, CR = Coefficient of reproducibility

RESULTS

The coefficient of reproducibility for each statement was calculated for the final selection of items by following the procedure discussed above. Items or statements were selected on the basis coefficient of reproducibility value equal to or greater than 0.85. We found that 13 statements had having reproducibility coefficient below 0.85. Therefore, 42 statements were retained in the final scale for assessment of the attitude of farmers towards scientific backyard poultry farming (Table 2).

Standardisation of scale-reliability and validity

The capacity of the testing instrument to provide a measurement score that is reliable, stable, and accurate when used

Table 1. Table showing responses and cutting points of various respondents for the statements (after eliminating statements having coefficient of reproducibility less than 0.85)

State-ments	Respon-dent	11	21	23	25	9	7	20	16	30	8	12	17	24	22	27	10	28	29	18	19	14	15	5	6	13	3	1	2	26	4	*f*	Error	Cr of State-ments
1	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X		x	x	x	29	3	
	0																											x				1	0	0.90
2	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	26	3	
	0																					x						x				4	1	0.86
3	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x												16	1	0.96
	0																x	x	x		x	x	x	x	x	x	x	x	x	x	x	14	0	
4	1	x	x	x	x																											4	0	1.00
	0					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	26	0	
5	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		29	0	1.00
	0																														x	1	0	
6	1	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x		x					23	2	0.90
	0												x											x		x		x	x	x	x	7	1	
7	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		29	0	1.00
	0																														x	1	0	
8	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		29	0	1.00
	0																														x	1	0	
9	1	x	x	x	x	x	x	x	x	x		x	x	x			x	x	x					x								16	1	0.86
	0										x				x	x				x	x	x	x		x	x	x	x	x	x	x	14	3	
10	1	x	x	x	x	x	x	x	x	x	x	x	x				x											x				14	1	0.86
	0													x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	16	3	
11	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	29	4	0.86
	0																										x					1	0	
12	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	28	3	
	0																							x				x				2	1	0.86
13	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	29	3	
	0																											x				1	0	0.90
14	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		2	0.93
	0																												x			1	0	
15	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	29	1	0.96
	0																													x		1	0	
16	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	28	3	0.86
	0																			x								x				2	1	
17	1	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x					24	0	0.93
	0											x		x														x	x	x	x	6	2	
18	1	x	x	x	x		x	x	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x					23	0	0.90
	0					x				x							x											x	x	x	x	7	3	
19	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x						22	0	0.90
	0																x	x	x								x	x	x	x	x	8	3	
20	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	29	4	0.86
	0																										x					1	0	
21	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		29	0	1.00
	0																														x	1	0	
22	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				27	0	
	0																												x	x	x	3	0	1.00
23	1	x	x	x	x	x	x	x	x	x		x	x	x								x		x								14	2	0.90
	0										x				x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	16	1	
24	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	29	4	0.86
	0																										x					1	0	
25	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					26	0	
	0																											x	x	x	x	4	0	1.00
26	1	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x					x		x						18	2	0.86
	0											x		x						x	x	x	x		x		x	x	x	x	x	12	2	
27	1	x	x	x	x	x	x	x	x	x	x		x	x	x			x	x	x	x	x	x	x	x	x	x	x				24	0	0.90
	0											x				x	x												x	x	x	6	3	

Table 1 contd....

State-ments	Respon-dent	11	21	23	25	9	7	20	16	30	8	12	17	24	22	27	10	28	29	18	19	14	15	5	6	13	3	1	2	26	4	*f*	Error	Cr of State-ments
28	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x								21	0	0.93
	0																				x		x		x	x	x	x	x	x	x	9	2	
29	1	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x					24	1	0.93
	0												x													x		x	x	x	x	6	1	
30	1	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x		x					23	0	0.90
	0												x											x		x		x	x	x	x	7	3	
31	1	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x				25	0	0.93
	0												x													x			x	x	x	5	2	
32	1	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x		x	x				24	3	0.86
	0											x												x		x			x	x	x	6	1	
33	1	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x		x		x									18	0	0.86
	0										x				x					x		x		x	x	x	x	x	x	x	12	4	
34	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				27	0	1.00
	0																												x	x	x	3	0	
35	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					26	0	
	0																											x	x	x	x	4	0	1.00
36	1	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x				24	2	
	0								x				x													x			x	x	x	6	2	0.86
37	1	x	x	x	x	x	x	x	x	x			x																			10	1	0.96
	0										x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20	0	
38	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x	x							21	0	
	0																x	x	x							x	x	x	x	x	x	9	3	0.90
39	1	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x		x	x			25	2	0.86
	0											x					x										x			x	x	5	2	
40	1	x	x	x	x	x	x	x	x		x	x	x	x	x	x																14	0	
	0									x							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16	1	0.96
41	1	x	x	x	x	x	x	x	x		x	x	x	x	x	x																14	0	
	0									x							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16	1	0.96
42	1	x	x	x	x	x	x	x	x			x	x				x															11	1	
	0									x	x			x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	19	2	0.90
Total Score		42	42	42	42	40	40	39	38	37	36	36	36	36	34	34	32	32	32	31	31	31	31	30	30	24	24	17	14	12	11	1260	97	

Table 2. List of final items in scale along with their coefficient of reproducibility for each item

S.No.	Statements	CR*
	Livelihood Aspects	
1.	I believe that scientific backyard poultry farming can significantly improve their overall livelihood.	0.90
2.	Scientific backyard poultry farming has provided me with an alternative livelihood, especially during agricultural off-seasons.	0.86
3.	By adopting scientific methods in scientific backyard poultry farming, I can better manage risks and uncertainties in their livelihood.	0.96
4.	Scientific backyard poultry farming allows me to diversify my income sources and reduce financial vulnerability.	1.00
5.	I am skeptical about the long-term sustainability of scientific backyard poultry farming due to external factors like market prices.	1.00
6.	I perceive scientific backyard poultry farming as a reliable and relatively low-investment source of additional income.	0.90
	Nutrition Aspects	
7.	Scientific backyard poultry farming enables me to produce fresh, nutrient-rich eggs and meat for family consumption.	1.00
8.	Scientific backyard poultry farming enhances food security by supplementing diets with affordable animal-based protein.	1.00
9.	I feel that Scientific backyard poultry farming has a positive impact on my children's health, improving their growth and development.	0.86
10.	Scientific backyard poultry farming ensures that I can have access to healthy and safe poultry products, free from harmful chemicals.	0.86
11.	I believe that scientific backyard poultry farming contributes to improved nutrition by providing essential micronutrients such as Fe, Zn and Vitamin B12 through eggs and meat.	0.86
12.	Through scientific backyard poultry farming, farmers have access to eggs and poultry meat as daily sources of high-quality protein.	0.86

Table 2 contd...

S.No.	Statements	CR*
13.	I appreciate the role of scientific backyard poultry farming in diversifying food sources, reducing dependency on single crops for nutrition.	0.90
14.	I am motivated to improve poultry nutrition practices, such as proper feeding & disease management, to increase productivity.	0.93
15.	I believe that the nutrition obtained from poultry products can help fight micronutrient deficiencies in rural communities.	0.86
	Income Aspects	
16.	I believe that scientific backyard poultry farming can generate consistent income if managed properly.	0.86
17.	Scientific backyard poultry farming helps me create new income streams, especially for women & young people in rural areas.	0.93
18.	Income from scientific backyard poultry farming is sometime used to meet essential family expenses like healthcare, education, and daily needs.	0.90
19.	I often report higher profit margins with scientific backyard poultry farming practices compared to traditional backyard poultry farming methods.	0.90
20.	Scientific backyard poultry farming opens opportunities for me to access better market prices for poultry products, resulting in higher profits.	0.86
21.	I am increasingly investing in scientific backyard poultry farming as a reliable source of supplemental income, especially in economically unstable regions.	1.00
22.	I believe that with higher technical knowledge of poultry farming tend to achieve better income outcomes compared to those without such knowledge.	1.00
23.	I believe that I might use income generated from scientific backyard poultry farming to reinvest in other aspects of their farming activities, ensuring long-term sustainability.	0.90
24.	I am able to sell backyard poultry products to local markets or even engage in small-scale poultry product processing for additional profit.	0.86
25	I sometime use the profits from Scientific backyard poultry farming to support other businesses or community development initiatives.	1.00
	Social Aspects	
26.	Scientific backyard poultry farming promotes social cohesion by creating opportunities for rural community collaboration and knowledge exchange.	0.86
27.	Scientific backyard poultry farming empowers women, giving them a means of economic independence and decision-making power in the household.	0.90
28.	I gain social recognition for being innovative and adopting modern agricultural practices when engaged in scientific backyard poultry farming.	0.93
29.	Scientific backyard poultry farming fosters social inclusion by enabling marginalized groups, such as landless labourers, to engage in income-generating activities.	0.96
30.	The success of scientific backyard poultry farming is often seen as a source of pride, contributing to improved self-esteem among farmers.	0.90
31.	In some communities, scientific backyard poultry farming has become a social norm, with neighbours helping each other in training, processing, and marketing poultry products.	0.93
32.	Scientific backyard poultry farming enhances rural social structures by creating a network of farmers who share resources, including feeds, vaccines, and technical knowledge.	0.86
33.	I often share scientific backyard poultry farming practices & experiences with neighbours, improving the overall productivity of the community.	0.86
	Technical and management aspects	
34.	I recognize the importance of adopting modern poultry breeds and scientific feeding techniques to optimize growth and production in scientific backyard poultry farming.	1.00
35.	Effective management practices such as proper housing, ventilation, and sanitation are considered crucial to maintaining a healthy and productive flock.	1.00
36.	I emphasize the need for regular health monitoring and vaccination schedules to prevent diseases & ensure poultry well-being.	0.86
37.	I believe that keeping accurate records of feed consumption, growth rates, and production levels helps in better decision-making and farm efficiency.	0.96
38.	Adopting biosecurity measures, such as disinfecting equipment and controlling farm access, is considered essential to reduce the risk of disease outbreaks.	0.90
39.	Technical support, such as access to veterinarians or agricultural extension services, is highly valued by me for trouble-shooting health and management issues.	0.86
40.	The application of sustainable practices, such as utilizing backyard poultry waste as fertilizer, is seen as an important part of long-term farm management and environmental responsibility.	0.96
41.	Proper financial management, including budgeting for feed, healthcare, and infrastructure, is seen as key to ensuring profitability in scientific backyard poultry farming.	0.96
42.	I believe that continuous training & education on new scientific backyard poultry management techniques help them improve productivity, reduce costs, and increase farm sustainability.	0.90

*CR = Coefficient of Reproducibility

repeatedly using the same instrument is known as reliability. It aids in determining how uniform the scale's objects are. Utilizing the split half method, which divides a scale into two halves depending on even and odd numbers of statements, the reliability of the current scale was determined. Between odd and even scores, the Pearson product moment correlation was 0.70. This coefficient represents the split half scale reliability. To adjust the split half reliability in to full test reliability, Spearman-Brown (1910) prophecy formula was used which is as follows:

$$R = \frac{2r}{1+r} = \frac{2\times 0.7}{1+0.7} = 0.82$$

Where, R= Reliability coefficient of the whole scale
r = Estimated correlation between two halves (Pearson r)

The whole test reliability was found to be 0.82 and found to be significant at 1 per cent level of significance as used by other authors (Singh et al., 2018; Shruti et al., 2019). Split half method is a popular method of assessing reliability of a test primarily for the advantage of single administration of the test and use of one sample. It aids in determining how uniform the scale's objects are. Cronbach's alpha was also used to get more stability and accuracy with the following formula:

$$\alpha_{standardized} = \frac{Kr}{[1+(K-1)r]}$$

Where, K = Number of items in scale
r = Mean of the K (K-1)/2 non-redundant correlation coefficients

The value of Cronbach's alpha calculated and found to be 0.845 which means scale is consistent in measurement. Similar reliability testing methods were used by various authors (Verma et al., 2024; Shruti et al., 2022; Kumar et al., 2021). Validity means ability of an instrument to measure what one intended to measure. The developed scale was tested for content validity. A panel of experts determined the content validity of the scale, which is defined as the representativeness or sample adequacy of the content, substance, matter, and themes of a measuring instrument (Kerlinger, 1987). For measuring content validity, statements were given to six experts, and a four-point scale was used.

DISCUSSION

The final 42 statements with CR value greater than 0.85 were retained. The scale is important as it captures the multifaceted benefits of scientific backyard poultry farming, including its role in providing an alternative livelihood, especially during off-seasons, and reducing financial risk through income diversification. It highlights improved nutrition and food security from access to fresh, nutrient-rich poultry products, contributing to better family health. The scale also reflects how poultry farming supports consistent income generation, empowers rural women and youth, and enables reinvestment into other farming activities. Socially, it promotes collaboration, inclusion, and recognition within communities. For example, scientific backyard poultry farming promotes social cohesion through forming self-help groups and encouraging group training programmes, etc. Additionally, it emphasizes the importance of technical knowledge, effective management, and sustainable practices for improved productivity and long-term success. Validity, reliability, and practicability become the three major dimensions to check for a measurement tool. Fair degree of validity depicted that judges agree that the specific statement (item) has content validity. Not only should the scale measure what it intends to measure, but it should also be done consistently when used among different samples. The reliability of the current scale was determined using split-half method. Between odd and even scores, the Pearson product-moment correlation was 0.70. Reliability scores of 0.845 showed a correlation between the statements, confirming the internal consistency.

CONCLUSION

By focusing on key dimensions such as livelihood, nutritional, income aspects, etc. the scale captures the unique aspects of scientific backyard poultry farming. This scale can be effectively used by researchers, policymakers, and extension workers to monitor progress, and design targeted interventions. The rigorous process, including item analysis, reproducibility checks, and reliability and validity testing, ensured the scale's precision and relevance. This tailored tool addresses gaps in existing attitude measures, providing a valuable resource for enhancing the understanding and management of backyard poultry farming and its productivity. Since the reliability and validity value of the scale shows the accuracy and consistency of the results, this scale can be used to assess the attitude of farmers towards scientific backyard poultry farming in a similar situation beyond the study area with suitable modifications.

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Research Tool

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Psychometric Validation and KR-20 Reliability of a Knowledge Tool for Semi-Intensive Pig Production

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HIGHLIGHTS

- Items with item difficulty (*P*) values ranging between 0.30-0.70 were retained.
- Items with item discrimination (*D*) value ≥0.30 were included in the knowledge test.
- Items with point-biserial correlation coefficient (r_pb) ≥0.30 were considered to be valid.
- *KR-20* coefficient ≥0.70, deemed the tool to be reliable and acceptable for the test.

ARTICLE INFO

Keywords: Dichotomous response, Internal reliability, Knowledge tool, KR-20, Scientific pig production, Semi-intensive, Validity.

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ABSTRACT

An instrument was constructed to assess the knowledge level of pig farmers with respect of scientific pig production under a semi-intensive rearing system. Primary review of relevant literature was the initial step in the identification of relevant items. A list of 42 items was prepared and then refined for preliminary assessment on sixty purposively selected pig farmers hailing from non-sampling areas. Data was collected during 2024-25, through direct questioning method using an interview schedule by registering dichotomous responses, "correct" and "incorrect", scored in binary format as "1" and "0", respectively for each item. The raw data was analysed to determine item difficulty (*P*) and item discrimination (*D*), which sorted thirty relevant items. Validity of selected items was confirmed through a point-biserial correlation test, with all items having an r_pb ≥0.30. The overall internal reliability of the knowledge tool was established by *KR-20* test, which yielded a coefficient value of 0.92, signifying very high reliability of the tool in measuring knowledge of pig farmers. The 30 items, encompassing five well-structured items under six major thematic dimensions, were incorporated to comprehensively assess the knowledge level of respondents. Based on equal class intervals, majority of respondents had medium level of knowledge.

INTRODUCTION

Globally, pig production constitutes the second most significant livestock industry, owing to consumer-driven demand for pork (Food and Agriculture Organization of the United Nations, 2011). The semi-intensive rearing system represents a modified form of the traditional scavenging approach, wherein pigs are typically housed within sturdy enclosures constructed from wood or durable fencing materials (Directorate of A.H. & Veterinary, Assam, n.d.). Distinction between intensive, semi-intensive and traditional backyard rearing systems are relatively minimal and rather blurred in developing countries, with visible overlapping of management

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practices (Conan et al., 2023). Studies show that small holder pig farmers operate their farms in hybrid blend of semi-intensive and backyard rearing system (Banik et al., 2021). The management of pig farms in developing countries of South and Southeast Asia are transitioning from scavenging to semi-intensive and intensive systems, with evident shift towards semi-intensive systems among smallholder pig farmers (Conan et al., 2023; Deka et al., 2014). Pig farming constitutes a significant component of India's agricultural sector, notably in the north-eastern region. Assam, in particular, hosts the highest pig population among all Indian states, with approximately 2.099 million pigs. The import value of pork, including fresh, chilled, and frozen varieties, rose from Indian rupee (INR) 22.6 crore in 2021–22 to INR 25.02 crore in 2022–23. This increase is likely due to the fact that pork production in India represents just 3.85 per cent of the country's total meat output of 9.77 million tonnes. (Ministry of Finance, Government of India, 2023). With projected increase in pork consumption by over 160.00 per cent in India by 2030 (Food and Agriculture Organization of the United Nations, 2011), the growing reliance on imports of this high-demand livestock commodity requires comprehensive analysis, and implementation of strategic measures, including the enhancement of domestic production chains and promotion of entrepreneurship, to counter import dependency.

Knowledge encompasses factual information, practical skills, and individual comprehension of a subject (Kesänen et al., 2014). Farmers who demonstrate innovation, recognize opportunities, effectively identify and utilize resources, and remain persistent in pursuing their objectives are more likely to achieve success (Chandraker et al., 2021). Factors such as education level, socio-economic status, interest in scientific practices, land ownership, social participation, and marketing abilities have a positive impact on the acquisition of knowledge (Sharma & Singh, 2023). Several knowledge tests developed to assess the scientific knowledge of pig farmers have been reliable instruments to analyse the knowledge level of pig farmers. However, these tools primarily focused on smallholder farmers, limited to backyard or scavenging-type rearing systems. Therefore, a need arose to ascertain the knowledge level of farmers who are shifting to a semi-intensive system of pig rearing. To address this, a tool was planned and tailored in accordance with the current trends in pig production using psychometrics to discriminate the level of difficulty of the test. Validity and reliability of the tool was done to assess its precision and consistency.

METHODOLOGY

The study was conducted during 2024-25, on sixty non-sample pig farmers practicing a semi-intensive system of pig production, residing in non-sample study areas of the six agro-climatic zones of Assam (Government of Assam, 2019). Psychometric analysis is the scientific process of measuring latent psychological attributes like knowledge, skill, attitudes, personality traits, or abilities using well-designed tools including questionnaires, tests, or scales (DeVellis, 2017). Systematic development, validation, and statistical evaluation of the tool ensure its reliability, validity, and accuracy as an instrument of measurement. The preliminary review of relevant literature and previously developed measurement tools was the first step in developing the knowledge tool. In accordance with Haladyna (2016), consultation with subject experts helped identify and design possible items for the preliminary schedule. A list of 42 items was initially prepared to design the knowledge test and administered to the intended respondents. The provisional knowledge test was administered to respondents to check the reliability and validity of the knowledge test. All items were given equal weightage, with binary scores of '1' attributed to correct responses, whereas '0' was marked for incorrect answers. The total score for each respondent was calculated by summing up the scores received for each item. Well-established methodologies in psychometrics and educational research for the construction and validation of survey tools were employed. The level of difficulty of selected items was ascertained using the item difficulty index (*P*) (Anastasia & Urbina, 1997). The degree to which an item discriminates between high-performing and low-performing respondents based on scores obtained in the knowledge test was calculated using the item discrimination index (*D*). A point biserial correlation test was conducted to validate each item within the construct. It is a measure of the relationship between a dichotomous variable and a continuous variable. The point-biserial correlation coefficient (r_pb) measures the degree to which performance on an individual item correlates with overall test performance, which helps to determine how well an item discriminates between high and low-scoring respondents (Allen & Yen, 2002; DeVellis, 2017). The reliability test is a measure to check the consistency and dependability of a measurement instrument. A reliable test gives similar results under consistent conditions. As dichotomous responses were registered, the internal reliability was checked using Kuder-Richardson Formula 20 (*KR-20*), formulated by Kuder & Richardson (1937).

RESULTS

Psychometric item analysis

Item analysis was conducted to evaluate how well individual items perform within a measurement tool during the developmental stage. Item difficulty index (*P*) is the proportion of respondents who responded to an item correctly to the total number of non-sample respondents selected for the preliminary test. (Anastasia & Urbina, 1997).

$$P_i = \frac{k_i}{K_i}$$

Where, P_i = difficulty index of the i^{th} item, k_i = total number of non-sample respondents who responded correctly to i^{th} item, K_i = total number of non-sample respondents selected for the preliminary test.

To calculate item discrimination (*D*), test responses were rearranged in descending order. Top one-fourth of total respondents, i.e., the high scorers (n_1=15) & bottom one-fourth, i.e., the low scorers (n_2=15) were identified as criterion groups. The scores obtained by these criterion groups was instrumental in measuring *D* value.

$$D = \frac{b_1H - b_2L}{b}$$

Where, *D* = discrimination index, b_1H = number of non-sample respondents in top 25 per cent (high score) group who answered correctly, b_2L = number of non-sample respondents in bottom 25

Table 1. Psychometric item analysis, validity and overall reliability of the knowledge tool

S.No.	Items	*P*	*D*	r_pb	*KR-20*
	Piglet care				
1.	At what age should piglets be given iron supplementation?	0.55	0.37	0.54	0.92
2.	Name one common disease affecting piglets.	0.42	0.33	0.51	
3.	Why is needle tooth removal practiced in piglets?	0.40	0.37	0.59	
4.	At what age is castration generally done in piglets?	0.53	0.30	0.51	
5.	When should piglets be weaned?	0.52	0.33	0.52	
6.	What is the average litter size in pigs?	0.75*	-	-	
7.	Why is nostril of piglets cleaned right after birth?	0.50	0.07**	-	
	Feeding				
8.	What is the average daily feed intake of pigs of 5-6 months age?	0.58	0.43	0.65	
9.	What is the average water requirement of growing pigs?	0.57	0.40	0.54	
10.	What are the crop by products that can be fed to pigs?	0.50	0.43	0.60	
11.	What type of cereal can be fed to pigs?	0.50	0.37	0.60	
12.	What are the animal protein supplement that can be fed to pigs?	0.48	0.40	0.65	
13.	Why should feeders or troughs be cleaned?	0.87*	-	-	
14.	What is the protein percentage required in pig starter feed?	0.28*	-	-	
	Breeding				
15.	What is the average gestation period of a pig?	0.62	0.33	0.50	
16.	Name a breed of pig	0.55	0.40	0.60	
17.	What is the ideal boar-to-sow ratio in a breeding unit?	0.38	0.33	0.57	
18.	How many litters can a sow produce in a year?	0.57	0.47	0.68	
19.	What is the ideal age of a gilt for first mating?	0.45	0.30	0.38	
20.	What is standing reflex?	0.22*	-	-	
21.	Which season is preferable for breeding pigs?	0.88*	-	-	
	Housing				
22.	What is the ideal floor space for a grower pig?	0.62	0.33	0.53	
23.	Why is proper drainage important in pig housing?	0.58	0.37	0.58	
24.	What is the preferred flooring material for pig pens?	0.48	0.40	0.61	
25.	How should pig houses be oriented?	0.58	0.40	0.59	
26.	Why is proper ventilation necessary in pig houses?	0.55	0.37	0.59	
27.	What is the primary reason for constructing drains in pig housing?	0.58	0.20**	-	
28.	Name a common bedding material used in pig houses.	0.75*	-	-	
	Health				
29.	How often should pigs be dewormed?	0.62	0.37	0.56	
30.	Name one vaccine recommended for pigs	0.55	0.40	0.60	
31.	Why should newly introduced pigs be quarantined?	0.52	0.43	0.68	
32.	Name one common disease affecting pigs.	0.48	0.37	0.56	
33.	Are classical swine fever infected pigs safe for consumption?	0.37	0.30	0.49	
34.	Which vitamin is essential to prevent rickets in pigs?	0.35	0.23**	-	
35.	What does deworming prevent in pigs?	0.72*	-	-	
	General management				
36.	What are the methods of carcass disposal?	0.60	0.37	0.58	
37.	Where should foot baths be placed?	0.30	0.33	0.52	
38.	What is the marketable weight for a grower pig?	0.70	0.33	0.53	
39.	Amount of manure generated by an adult pig per day?	0.65	0.40	0.59	
40.	What is the dressing percentage of pig?	0.62	0.37	0.52	
41.	Name one disinfectant used in pig farms.	0.78*	-	-	
42.	How many times in a day should feed be provided to pigs?	0.35	0.23**	-	

Note: '*' items with *P* values not ranging between 0.30-0.70; '**' items with *D* values <0.30

per cent (low score) group who answered correctly, *b* = total number of non-sample respondents in top 25% (high score) group (n_1=15) and bottom 25% (low score) group (n_2=15), i.e., 30 in this case.

Table 1 presents the final set of 30 items deemed relevant and valid for inclusion in the knowledge test, following the stepwise elimination of items that did not meet the specified criteria. The items with *P* values ranging between 0.30-0.70 (moderate) were deemed optimal and retained, whereas, items with *P* values < 0.30 (difficult) or, > 0.70 (easy) were discarded to preserve test balance. Items with *D* value ≥0.30 were included in the tool, as they denoted good discrimination, whereas, items with *D* value <0.30 were considered poor, and were dropped (Hopkins, 1998; Kline, 2000).

Validity of selected items

Items with point-biserial correlation coefficient (r_pb) ≥0.30 were considered to be valid (Table 1). The analysis was done using Jamovi (*Version: 2.6.26.0*) statistical software.

$$r_pb = \frac{\mu_1 - \mu_0}{s} \sqrt{\frac{p\,q}{N}}$$

Where, μ_1 = mean of the continuous variable for group with value 1, μ_0 = mean of the group with value 0, s = standard deviation of the continuous variable, p = proportion of 1s, q = proportion of 0s (i.e., q = 1- p), n = total number of observations

Reliability of the tool

The *KR-20* coefficient was calculated for the selected 30 items sorted after psychometric analysis and validity test. The *KR-20* coefficient value was ≥0.70, i.e., 0.92 (Table 1), hence the tool was deemed to be reliable and accepted for the test.

$$KR\text{-}20 = \frac{c}{(c - 1)} \left[1 - \frac{\Sigma\, d_i\, q_i}{\sigma^2}\right]$$

Where, c = total number of items, d_i = proportion of respondents who answered item i^{th} correctly, q_i = 1 - d_i, i.e., the proportion of respondents who answered i^{th} item incorrectly, σ^2 = variance of the total test scores.

Assessment of knowledge level

A total of 30 items were finally included in the schedule, encompassing five well-structured items under six major thematic dimensions, viz. “piglet care”, “feeding”, “breeding”, “housing”, “health” and “general management”, to comprehensively assess the knowledge level of non-sample respondents. The total score for all the items ranged between 0 to 30. The respondents were categorised into low, medium and high knowledge groups based on equal class intervals as presented in Table 2. It can be observed in Table 2 that majority of the farmers fell under medium level of knowledge, followed by those in high and low knowledge level categories, respectively.

Table 2. Distribution of respondents based on knowledge level (n=60)

Knowledge level	Class interval	Frequency
High	21-30	16
Medium	11-20	29
Low	0-10	15

DISCUSSION

The items selected preliminarily were useful in identifying the gap in knowledge of the farmers. The use of binary scoring of responses allowed for simplicity in administration and interpretation, which is crucial for field-based studies. The interpretation for item difficulty (*P*) and item discrimination (*D*) was done based on widely established literature relevant to classical test theory. The item difficulty (*P*) test yielded items that were considered moderately difficult and were retained for inclusion in the final tool. Items that were too difficult or very easy to respond to were siphoned and eliminated from the final schedule. Retention of items based on item discrimination (*D*) test values ≥0.30 confirmed their capacity to distinguish between high and low performers. Similar methodology was employed by Kumar et al., (2016); Maji (2018); Vijayan et al., (2022); Vijayan et al., (2023) in their study. The point-biserial correlation coefficients (r_pb ≥0.30) further support the individual item validity, confirming each item’s ability to reflect real differences in knowledge among respondents. Johnson et al., (2023) adopted similar evaluation criteria in their study on the development of a tool to assess knowledge of tribal organic poultry farmers. These criterions enhanced the overall sensitivity of the tool to detect variations in knowledge level among respondents. The *KR-20* coefficient of 0.92 signifies excellent internal consistency, reaffirming the reliability of the test instrument. Coefficients below 0.70 were considered to be poor. A high reliability metric is indicative of a minimal measurement error, implying that the tool consistently measures the construct of scientific piggery knowledge across multiple domains, which establishes robustness of the analytical framework. Mukhopadhyay et al., (2020); Ntumi et al., (2023) and Powell et al., (2017), utilised this test to measure the reliability of their tools. The provisional study revealed that majority of the respondents possessed medium level of knowledge with respect to scientific pig production. The findings are in line with those of Verma et al., (2007) in their study on knowledge level of tribal pig farmers regarding scientific pig farming. The items covered under different dimensions of pig farming can act as a solid tool to assess dimension wise knowledge of the farmers in respect of scientific pig farming. This tool also serves dual function, as a reliable measurement instrument, and as a diagnostic guide to identify gaps in knowledge. Its thematic structure aligns with the core competencies required for successful pig farming and is adaptable to training programs, monitoring initiatives, and policy interventions aimed at promoting sustainable piggery practices in India.

CONCLUSION

This study successfully developed and validated a knowledge assessment tool designed to evaluate the scientific awareness of pig farmers engaged in semi-intensive production systems. The instrument offers a standardized method to categorize farmers by their knowledge level, enabling targeted extension interventions. It can also serve as a benchmark for future studies assessing the impact of training programs or policy changes in pig husbandry. Given the increasing reliance on pork as a protein source in north-eastern region of India and the strategic importance of Assam in domestic pig production, such tools are indispensable as it provides empirical grounding for capacity-building initiatives and can help reduce the knowledge-attitude gap that often hampers livestock productivity. Future studies may consider adapting this tool for digital administration or expanding it to include attitudinal and practice dimensions, thereby providing a holistic understanding of adoption of new technologies in pig farming.

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Research Tool

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Scale to Measure the Attitude of Farmers towards the Maize and Wheat Crops

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HIGHLIGHTS

- Reliability of the Maize crop's scale was higher (0.80) than the wheat crop's scale (0.71).
- For the Maize crop, 13 items were finally retained out of 26 items, whereas 11 items were retained from 27 items, in terms of the Wheat crop.
- The development of this scale provides valuable insights into the decision-making processes of farmers.

ARTICLE INFO

Keywords: Attitude, Cronbach alpha, Reliability, Internal consistency.

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Informed consent of the participants

ABSTRACT

Attitude plays a critical role in shaping one's behavior towards any psychological object. Scales were created to examine farmers' attitudes on maize and wheat crops. A list of 26 attitude statements for maize crop and 27 attitude statements for wheat crop was compiled and improved using Edward's 14 principles, and included both positive and negative remarks. The study was conducted in 2024 with a total of 56 farmers in the sub-tropical zone, which included districts such as Akhnoor, Samba, and Kathua, and 56 farmers in the mid-hill zone, which included districts such as Rajouri, Kishtwar, Ramban, and Doda. Ultimately, each statement's "t" value was calculated, and found that 13 statements for the maize crop and 11 statements for the wheat crop had a "t" value higher than 1.75, which were retained in order to assess the final scale's validity and reliability. Cronbach's alpha was proposed for assessing the reliability of attitude scales. In the case of scale for maize crop, the Cronbach's alpha coefficient was 0.81, and 0.71 in the case of the wheat crop, validating the constructed scale's internal consistency. The experts' opinions were used to determine the scale's content validity. With some changes, the ultimate scale will be used to gauge the attitude of farmers toward the maize and wheat crops.

INTRODUCTION

As the main source of income for the vast most of the world's impoverished, agriculture plays a crucial role in the 2030 Agenda and is a key means of accomplishing many of the Sustainable Development Goals (SDGs) (Erenstein et al., 2021). As a result, agri-food systems are essential in fulfilling the 2030 Agenda for Sustainable Development's 17 Sustainable Development Goals. Eight nations–the United States, China, Brazil, Argentina, Ukraine, Indonesia, India, and Mexico–produce more than 25 million tons of maize every year, which combined make up 881 million tons, or three-quarters of the world's total production (Fanzo et al., 2021). Maize is a crop that can be used for many purposes. The main applications of maize (dry grain) worldwide are as feed (56% of production), non-food purposes (5%), and food (13%). It is predicted that 35 per cent of farms worldwide will grow maize by 2030, up from 33 per cent in 2020. Particularly dynamic is China, whose contribution to the anticipated worldwide fall in farm numbers is probably being driven by its fast economic change, urbanization, and farm consolidation (Erenstein et al., 2021). India's economy is undergoing change as well; rising demand for poultry is driving up maize output (Hellin et al., 2015). One of the most

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significant staple crops that significantly contributes to global food security is wheat (*Triticum aestivum*). It supplies 20 per cent of global human caloric intake. Bread, cereal, rusks, biscuits, pasta, cookies, noodles, and other wheat-based foods frequently include these calories. The area cultivated with cereals in the world is 840 million hectares, of which 227 million hectares is under wheat. Wheat is grown as a staple crop in more than 180 countries around the world. However, the yield is much lower than the allowable level of 2.71 t/ha. This meets 60 per cent of the population's grain needs (Dilmurodovich et al., 2021). Since almost 65 per cent of J&K's population makes their living either directly or indirectly from agriculture, it is a significant part of the state economy. Concerns about decreasing productivity, environmental degradation, and ecological unsustainability should be prioritized for the long-term expansion of agriculture in Jammu and Kashmir, in addition to achieving food and nutritional security. Low crop yield, which is reflected in the small average size of holdings, is the state of J&K's economic worry, highlighting the need for sustainable agriculture (Khan et al., 2018). To sum up, small farm management can significantly contribute to overall sustainability by increasing the farming system's production, profitability, and sustainability (Narayan, 2012).

METHODOLOGY

Likert's Summated Rating attitude scale construction technique was employed to construct a scale for the objective. Subject-centered discrepancies among responders regarding their possession or status of a certain attribute or feature are measured using the Likert scale. (Ramya et al., 2019). To examine the correlations between items and scales, Likert scale with a continuum of five or seven points can produce sufficient variation and internal consistency (Lissitz, 1975). We chose to use the five-point continuum scale. A total of 35 pertinent attitudinal items spanning various facets of growing maize and wheat crops were gathered following a thorough assessment of pertinent literature, discussions with farmers, and the experience of the investigator. Out of 35 items, 26 for maize crop and 27 statements for the wheat crop were kept for additional examination if they met Edwards' (1969) requirements for building an attitude scale. These 26 statements for maize crop and 27 statements for wheat crop were administered to 56 farmers in the sub-tropical zone, which included districts namely Akhnoor, Samba, and Kathua and 56 farmers in the mid-hill zone, which included districts namely Rajouri, Kishtwar, Ramban, and Doda. To measure farmers' degrees of agreement, a five-point continuum scale was created, where 5 denoted highly agree and 1 denoted strongly disagree. The t value for each question was then calculated using the scores of the selected respondents. The results of the item analysis displayed the t-value for each item.

$$t=\frac{\bar{X}H-\bar{X}L}{\sqrt{\frac{\sum(X_H-\bar{X}_H)^2+\sum(X_L-\bar{X}_L)^2}{n(n-1)}}}$$

Whereas,

$$\sum(X_H-\bar{X}_H)^2=\sum(X_H)^2-\frac{(\sum X_H)^2}{n} \text{ and } \sum(X_L-\bar{X}_L)^2=\sum(X_L)^2-\frac{(\sum X_L)^2}{n}$$

Items that had a t-value greater than 1.75 were retained. In this way, 13 statements for maize crop and 11 statements for wheat crop were retained that will be further administered to 288 non-sampled respondents for the study. The reliability of 26 statements for the maize crop came out to be 0.81, and for 27 statements for the wheat crop came out to be 0.71.

RESULTS

The uniformity of several measurements of a variable is referred to as reliability. The reliability of the measurement device was evaluated using the Cronbach alpha coefficient (internal consistency). In research, a Cronbach alpha value of 0.7 or higher is ideal, although in certain cases, a Cronbach coefficient of 0.6 or higher is also considered sufficient to confirm the accuracy of the measurement apparatus (Nunnally & Bernstein, 1994).

Maize crop

The chosen attitude scale items that passed the item analysis (t-value of 1.75 or higher, computed), as shown in Table 1, are displayed. Thirteen statements were ultimately kept in the developed tool out of the 26 statements for the total pooled items for the maize crop. Any attitudinal item with a t value more than 1.75 has higher discrimination power and was retained in the final scale, following Edwards (1969). The scale has a good degree of

Table 1. A scale with corresponding t-values to gauge farmers' attitudes toward the maize crop

Statements	t-value
Maize is cultivated less than any other crop in that season.	6.99
Maize is used in industries for the production of bio-ethanol.	6.18
Hybrid maize is preferred more as it reduces the crop loss due to crop pests.	1.86
Lack of drainage practice at the time of sowing destroys the crop.	7.64
Maize is the most suited cereal crop for poultry feeding.	3.58
Monkey menace is the major problem restricting farmers from undertaking maize cultivation.	5.86
The selling of green cobs fetches more money to the farmers.	2.88
The maize crop is more prone to human and bird pilferage.	3.21
Intercultural operations in the maize crop are more time-consuming.	4.60
Progressive maize cultivators can motivate fellow farmers to adopt their cultivation.	6.08
Maize fodder is the most promising material for silage/forage making.	2.90
The maize crop is more labour-intensive as compared to the other crops grown in the same season.	5.87
The maize crop can withstand moisture stress conditions.	11.36

Table 2. Scale to measure the attitude of farmers towards the wheat crop with their respective t-value

Statement	t-value
Wheat cultivation is more economical as compared to other crops grown in that season.	2.53
Inputs required for wheat cultivation is not easily available.	3.35
Wheat cultivation is the most suited option in Rainfed/Kandi/Mid-hill areas.	1.79
The government has initiated various programmes for wheat promotion in the country.	5.61
Wheat is an important crop in the NFSM mission.	7.14
Farmers are less inclined towards processed products of wheat.	2.12
Wheat cultivation is not successful in less fertile soil.	2.02
Farm mechanization is not satisfactory in wheat cultivation.	3.76
Varietal diversification is satisfactory in the wheat crop.	3.51
Wheat is an important crop in the crop rotation cycle.	3.00
Preparation of traditional value-added products of wheat is a very common practice in kandi/mid-hill areas.	3.39

consistency in its measurement, as seen by the calculated Cronbach alpha coefficient of 0.80 for the maize crop (Table 1).

Wheat crop

The attitude scale items that were chosen and passed item analysis (calculated t value of 1.75 or above) are shown in Table 2. Eleven elements were ultimately chosen from the 27 assertions for the total pooled items of the wheat crop in the instrument that was built. Edward (1969) asserts that any attitudinal component with a t value above 1.75 has a larger capacity for discriminating and may be included in the final scale. The created scale's calculated Cronbach alpha coefficient for the wheat crop was 0.71 (Table2), which was deemed credible.

DISCUSSION

If a scale measures what it is intended to measure, it is considered legitimate. It is the degree to which a scale accurately depicts the concept or idea of interest. The sample size or representativeness of the content about the universe's content is known as content validity. To confirm the present scale's content validity, experts were engaged and comments were collected from relevant literature. Researchers (Gupta et al., 2022; Bardhan et al., 2023; Reddy et al., 2023., Velamuri et al., 2024; Boora et al., 2022; Vavilava et al., 2024; Saikia et al., 2024; Chandra et al., 2024) employed a variety of techniques to estimate validity and dependability.

CONCLUSION

Development of a standardized scale to measure the attitude of farmers towards maize and wheat crops represents a significant step forward in agricultural research and practice. The scale's robustness in capturing various dimensions of farmer attitude ensures its utility in tailoring more effective interventions and support systems for farmers. Future studies could build upon this work by further refining the scale, exploring regional variations, and investigating how attitude correlates with socioeconomic factors, technology adoption, and sustainability practices. Ultimately, a well-informed approach to understanding farmers' attitudes can lead to improved crop management strategies, higher productivity, and better-informed agricultural policies. This research emphasizes the importance of considering the farmers' perspectives in agricultural development and underscores the need for tools that can capture their complex and diverse attitudes toward crop cultivation.

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Research Note

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Interpersonal Communication Skills in Shaping Academic Performance among University Students

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HIGHLIGHTS

- Communication skills are one of the most indispensable skills for students enrolled in academics for their holistic growth.
- The role of interpersonal communication in an educational setting is foundational for a smooth, successful learning process.
- Module, an extra-curricular activity designed to enhance communication skills, will prove picturesque for university students.

ARTICLE INFO

Keywords: Communication proficiency, Emotional expression, Undergraduate students, Academic outcomes, Communication levels.

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Informed consent of the participants

ABSTRACT

Excellent academic performers need good communicative students who must have the skill to represent their thoughts and ideas with clarity and confidence, whether verbally or non-verbally. It's about upholding skills of transmitting knowledge and information systematically channeled through the presentation of written form, easy for others to understand. The study aimed to find out communication skills academically and their value in encompassing academic performance among students enrolled in undergraduate courses in various faculties of Banaras Hindu University, Varanasi, 2024. Responses were obtained from 111 total respondents, both boys and girls, based on the communication skill inventory. The data was collected using a closed-ended self-structured questionnaire using a simple random sampling technique. The results were analyzed using SPSS version 16, which showed levels of achievement from moderate to high levels of communication skills in listening, speaking, reading, and presentation skills. The result shows that the majority of the students agreed that their communication skill level falls at a moderate level.

INTRODUCTION

A message when transmitted via a particular medium that involves systematic steps of sending to receiving, and then giving feedback as a whole is called communication; it is fundamentally applied to spheres of life (Katherasala & Rao, 2023). Communication is a compilation of multiple skills engaged in informing, educating, and motivating; it even works towards whisking, swapping, or modifying behavior. Interpersonal communication is said to be a set of affective cognitive, social behavioral skills through which individuals express emotions, and give and take information, they tend to do conversation to express themselves, it is the joint understanding among individuals for successful social survival (Febrianita & Hardjati, 2019). Interpersonal skills are a pivotal factor in shaping communication which develops expertise in sharing opinions, emotions, and feelings. It improves relationships by deepening connections at home with family members, and at work improving teamwork cooperation, coordination, and decision-making, it helps and improves establishing relatedness between one another (Mali & Patil, 2023). The emergence of communication came with the revolution of humankind and it eventually became the most important of human life historically, humans constantly communicate even before they take birth they communicate through and inside the mother's womb. Communication makes it easy to be a social entity (Karasu & Faiz, 2020).

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Academic achievements are often termed academic performance; they are a component generally used in terms of student academic performance in school, college, or university. It typically does not include music or sports but calculates the performance of students in the laboratory, library, or fieldwork (Chacko, 2019). Skill or knowledge-based performance of an individual in given certain criteria academically, which is decided by certain scores, grades, and marks distinct by the institution, school, or college, is called academic achievement. It is an important part of the academic life of an individual as it works as a pillar of strength and confidence through walks of life, it gives recognition and promotion, to individuals. Academic achievement of an individual cannot be ignored, indeed it acts as a source of motivation (Ramana & Kausalya, 2012). Nain & Trikha (2009) study highlights about training needs and preferences of farm journalists, regarding journalism for effective persuasion of communication and information flow through the means of journals and periodicals available from governmental and non-governmental sources, which demands a continuous flow of training for this professionalism and to produce crisp participatory communication. For participatory communication, the journalist and writer must gear up about their readers' mindset, context, and situation; they must be clear about the layers of journalism to be professional and develop a better understanding of their readers and audiences.

METHODOLOGY

This study used a cross-sectional research approach to investigate undergraduate students' interpersonal communication abilities and how they relate to academic achievement. 111 undergraduate students from Banaras Hindu University, a well-known university in India, took part. To ensure a broad sample, these students were enrolled in a range of three-year graduation courses. Because the participants' ages ranged from 17 to 25, people at various phases of their college studies could be included. A pre-structured questionnaire was used to collect data. This tool was painstakingly created to gather comprehensive data regarding the student's academic achievement and interpersonal communication abilities. The questionnaire was divided into several sections, each of which focused on a distinct facet of communication abilities, such as empathy, active listening, rapport-building, verbal and nonverbal communication, and more. It also contained information about the student's academic achievement, including grades, attendance, and involvement in class activities.

To guarantee accuracy and consistency in data collection, the participants were given the questionnaire in a controlled environment. Participants received a briefing on the goals and methods of the study before the questionnaire was distributed. They were told that participation was entirely voluntary and that their answers would be kept private. All participants gave their informed consent. The Statistical Package for Social Science (SPSS) version 20 was used to thoroughly analyze the gathered data. Because of its strong analytical skills, this statistical program is frequently utilized in social science research. Frequency, mean, standard deviation, and chi-square were computed to provide an overview of the participants' demographics, including age distribution. This made it easier to comprehend the overall traits of the research population and gave a clear picture of the sample's makeup. To establish statistical significance, a p-value criterion of less than 0.05 was established. Accordingly, a p-value below this cut-off would suggest a statistically significant outcome, giving assurance that the correlations found were not the result of chance.

RESULTS

The data indicates that a significant proportion of individuals (32.7%) do not find it characteristic to feel comfortable while speaking to strangers. However, a notable percentage (34.5%) find it moderately characteristic. A large proportion (37.6%) find it very characteristic to feel tense and insecure in most social gatherings. This indicates that social anxiety is a prevalent issue among the individuals surveyed. The data suggests that 32.7 per cent of individuals find it very characteristic to have difficulty getting along with new people, highlighting potential challenges in forming new social connections. A significant percentage (36.4%) of respondents agreed that they find it difficult to choose the right words to express themselves, indicating challenges in verbal communication. The table sheds light on various social behaviour traits, with a considerable number of individuals experiencing discomfort, tension, and communication challenges in social settings. These insights may be

Table 1. Distribution of respondents based on their emotions (relaxation or comfort level)

Particulars	Not all characteristics of me (%)	Not really characteristic of me (%)	Moderately characteristic of me (%)	Characteristic of me (%)	Very characteristic of me (%)
Feel relaxed and comfortable while speaking to strangers	19.1	32.7	34.5	6.4	7.3
Feeling tense and insecure in most social gatherings	16.5	18.3	26.6	0.9	37.6
Difficult to get along with new people	10.9	20.9	26.4	9.1	32.7
Difficult to find right word to express oneself	10.9	20.9	27.3	36.4	4.5

Table 2. Distribution of respondents on their perception of academic performance

Particulars	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
Communication Skills Impact Academic Performance	2.8	3.7	19.4	43.5	30.6
Communication Skills increase confidence, which directly boosts academic performance	1.8	2.7	10	49.1	36.4
Incorporation of communication skills in the curriculum will improve academic performance	3.6	3.6	16.4	45.5	30.9

valuable for designing interventions to improve social skills and reduce anxiety in interpersonal interactions.

Table 2 this demonstrates that the majority of respondents (74.1%) either agree or strongly agree that communication skills have an impact on academic performance, indicating a significant recognition of the importance of communication skills in educational contexts. A substantial proportion of respondents (85.5%) agree or strongly agree that communication skills boost confidence, which in turn enhances academic performance. This underscores the perceived interrelationship between communication skills, self-confidence, and academic success. The majority of respondents (76.4%) are in agreement or strongly agree that integrating communication skills into the curriculum will lead to improved academic performance. This suggests strong support for educational interventions that include communication skills training. The table reflects a strong consensus among respondents on the positive impact of communication skills on academic performance. Most individuals agree that communication skills not only directly affect academic success but also boost confidence, which further enhances performance. There is also considerable support for the inclusion of communication skills training in educational curricula to improve overall academic outcomes.

In the Table 3, the Communication level of students from urban areas was high. Less than a quarter of the respondents (21) who were from semi-urban areas said that their communication level was moderate. (20) Rural respondents agreed that their communication level was low. The chi-square test was computed to determine the association between students from different demographic areas and their communication skill levels. A null hypothesis was formed to 'there is no association between demographic area and student's communication skill level'. The analysis shows that the differences among students and their communication skill levels are significant. X^2 (4, N=111) =20.769, p= 0.000. Thus, the null hypothesis was rejected. The study reveals that there is not any significant difference in communication skills between male and female students, it was found that they have similar levels of communication skills among, students from urban and rural backgrounds possessed to have alike communication level studying in university, but all the students enrolled have had fairly good catch communication proficiency Shah et al., (2020). The level of communication skills level between genders. Less than half of the female respondents (11.7%) said that their communication skills level is high followed by male respondents (15.95%) who thought that their communication skills level was moderate. The chi-square test was computed to determine the association between students from different demographic areas and their communication skill levels. A null hypothesis was formed to 'there is no association between male and female students and their communication skill level'. The analysis shows that differences among students and their communication skill levels are significant. X^2(2, N=111) =7.366, p= 0.025. Thus, the null hypothesis was rejected.

Table 4 demonstrates those students whose communication skills were high and said that their communication skills are a factor in their academic performance. The chi-square test was computed to determine the association between communication skills and academic performance. A null hypothesis was formed to 'there is no association between level of communication skills and academic performance'. The analysis shows that differences among students and their communication skill levels are significant. X^2 (8, N=111) =18.799, p= 0.016. Thus, the null hypothesis was rejected. The majority of the students (20) whose communication skill level was on the moderate level agreed that their academic performance in classrooms as well as outside is an indicator of their communication skills.

Table 3. Communication proficiency levels were used to group individuals

	Score/Communication level (%)			Total	p-value
	High	Moderate	Low	(N=111)	
Semi-urban	2.96	7.77	2.96	37	0.000
Rural	1.85	4.44	7.4	37	
Urban	6.29	5.18	2.22	37	
Total	30	47	34	111	
Identity	Communication level (%)			Total	p-value
	High	Moderate	Low		
Girl	11.76	10.08	9.52	56	0.025
Boys	4.95	15.95	9.35	55	
Total	30	47	34	111	

Table 4. Distribution of respondents based on their communication skills and academic performance

Communication level	Academic Performance					Total	p-value
	Agree (%)	Disagree (%)	Neutral (%)	Strongly agree (%)	Strongly disagree (%)		
High	2.4	0.9	2.7	2.7	0.3	30	0.016
Moderate	9.4	4.23	5.17	2.39	0	47	
Low	6.12	1.02	2.72	0.34	1.36	34	
Total	46	15	28	17	5	111	

DISCUSSION

Sabbah's (2020) study suggests that there is no major difference in the communication skills of students enrolled in university based on gender or demographic factors, the study revealed that enrolled students had good command over communication because the university as an educational institution provides opportunities to its students to sharpen their skills through group discussion, interaction, and social communication at various stages. Braun (2021) highlights how a higher educational institution plays a crucial role in molding the communication skills of enrolled students, The University is giving importance to communication skills by declaring it as a competence to act for the procurement of knowledge and cognitive achievement. Haqwar et al., (2025) study was conducted on the usage of information and communication technologies which is one of the important tools for educational advancement, for accurate coding, storage, retrieval, dissemination, and transmission of data for enrichment of knowledge, improving decision-making capacity, problem-solving ability, positively impacting communication between student and teacher, the overall embrace of ICT can give expected outcomes, enhance and strengthen result in all around fields. Sikdar et al., (2025) investigated a study conducted among the students, stating that students were in favor of training programs specifically for communication in their initial academic years or before completion of the academic degree program. It is found in the study that students enrolled in universities come from rural backgrounds hold a strong grip on their industrial profession; they need profound communication skills, to upscale participation of students in the industry. there is an urgent need to develop courses, and training programs to sharpen communication especially oral and written communication skills. Yulikhah et al., (2019) successful communication is a major determinant of students' preaching, and learning though not all students have good command over interpersonal communication skills, it can be indeed achieved through developing self-concept and self-efficacy which means how students perceive themselves to be ideal selves.

Swanson (2018) explored the study speaks about the skills of university students regarding communication, they generally prefer face-to-face communication along with face-to-face interaction use of technology, the study reveals their mode of communication in various scenarios, for academic communication mostly students use email and text messaging, they rather use less social media like Facebook for academic communication, however, university students smartly merge technology innovativeness while communicating to improve the impact of communication. Meinam et al., (2023) study talks about students' educational aspirations among students and influencing factors. Academic achievement is said to be how a student, completely based on their ecosystem, mental attributes, and physical strength defines educational boundaries and how much goal has to be achieved, according to well-prepared plans within the academic context because ultimately the goal defined by students makes it different from other and defines its aura both personally and professionally. Sampithrao (2016) communication is highly influenced by self-concept and self-esteem, communication becomes smooth when these both are blended into it, and people tend to be more generous, understanding, forgiving, responsible, and genuine. Communication becomes gracious when a person is clear about self-concept which indicates involvement of self attributes like inner confidence, thoughts strengths, and weaknesses it, is not merely limited to physical involvement. Students who are pro in this skill have good command over language through which they explain their ideas better which is fundamental for social and professional success. Besides this can be recommended to teach communication skills as part of the curriculum or vocational skills in faculties of the university which will enhance students' written, and speaking skills primarily followed by listening skills.

CONCLUSION

Students enrolled in universities must be given exposure to vocational activities for communication skill learning from the early years of enrollment to prepare them for the challenges of the globalized world and open new platforms to work professionally. Interpersonal communication skills are essential for the maintenance of human relations in the social system with the workplace, community, friends, and family. Students enrolled in higher education tend to develop their relations with their peers, teachers and outside based on many factors like family, language, ethnic group and culture, political influence, and most importantly interpersonal communication skills. The role of interpersonal communication in an educational setting is foundational for a smooth successful learning process. The key factor is, that communication when practiced in a classroom setting between educators and students creates a positive atmosphere enforcing an environment of understanding, self-esteem, concentration, and closeness, impacting altogether the academic settings.

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Research Note

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Barriers Hindering Tribal Farm Women's Access to Agri-Allied Information

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HIGHLIGHTS

- Domestic chores and high drudgery limit tribal farm women's access to agricultural information and training.
- Long distances to markets and poor transport hinder women's exposure to agricultural innovations.
- The high cost and complexity of digital tools reduced effective communication and information access.
- Inflexible training schedules and male-dominated environments deter women's participation in extension programs.
- Lack of formal education and awareness restricts the adoption of modern agricultural practices and ICT tools.

ARTICLE INFO

Keywords: Constraints, Tribal areas, Farm women, Information, Accessibility, Garrett ranking.

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ABSTRACT

Tribal farm women play a crucial role in agriculture, household maintenance, and resource management while upholding cultural and ecological practices. However, limited access to agricultural information impedes inclusive development. To examine these challenges, an ex-post facto study was conducted in Odisha to identify the constraints they encountered. A sample of 240 respondents from two districts was selected through multi-stage random sampling, with data collected via semi-structured interviews. Key socio-personal issues included dominance of domestic work (63.55) and increased drudgery (56.63). Under extension and training, lack of resources (62.97) and unsuitable programme timing (59.41) were prominent. Marketing challenges involved distant markets (72.53) and poor transport (56.44), while communication barriers included high cost (73.24) and tool usability issues (59.39). Tackling these challenges through a holistic, solution-focused approach is essential to improve tribal women farmers' access to agricultural information and enhance their overall informational reach.

INTRODUCTION

In agrarian economies such as India, agriculture forms the backbone of livelihoods, and women play an indispensable role in the production of staple food crops. According to the Census of India (2011), 47.20 per cent of male workers were categorized as "other workers," whereas 55.21 per cent of female workers were engaged in agriculture, highlighting the significant contribution of women in this sector. Specifically in Odisha, 61.8 per cent of the total workforce was involved in agricultural activities, with women constituting 64.4 per cent. This figure increases to 76.9 per cent among rural women (National Sample Survey Office, 2024), reflecting the gendered dimension of agricultural engagement in the state. Odisha is distinguished by its tribal diversity, being home to 62 tribal communities that constitute 22.1 per cent of the state's population. Notably, 94.5 per cent of this tribal population resides in rural areas, living in close proximity to nature (Nayak, 2015; Palo et al., 2020), who have been historically excluded from mainstream development. In tribal communities, women comprise nearly half the population and serve as the foundation of the agricultural workforce. They undertake strenuous tasks in agriculture, animal husbandry, and domestic spheres, often working long hours even during pregnancy (Dagar & Upadhyay, 2022). Tribal women undertake diverse roles including caregiving, agricultural labour, livestock rearing, water collection, and food preparation (Gioli et al., 2019; Javed et al., 2024). Their limited integration into

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formal knowledge systems and market structures, coupled with restricted access to productive resources, significantly impedes the socio-economic progress of tribal communities (Panda, 2021). Although tribal women play a pivotal role in ensuring food security and sustaining agrarian livelihoods, their efforts remain largely undervalued and thus facing deeper layers of marginalization than their male counterparts, despite their multifaceted contributions to domestic and economic spheres. One of the critical barriers to enhancing their productivity is the lack of access to timely and relevant agricultural information (Ansari & Sunetha, 2014). Access to knowledge is fundamental for agricultural innovation and sustainable development (Jat et al., 2021). However, insufficient awareness regarding improved inputs, modern technologies, and recommended practices continue to hinder productivity in developing regions (Adebisi & Martins, 2020; Magruder, 2018; Lecoutere et al., 2023). Tribal farm women have specific informational needs related to crop disease management, high-yield varieties, fertilizer application, improved implements, value addition to forest products, and animal husbandry (Ansari & Sunetha, 2014). Nevertheless, their primary sources of information are informal, including family members, friends, and community leaders, rather than formal agricultural extension systems (Sharma & Singh, 2016). Their communication patterns are typically open and participatory, with knowledge-sharing occurring predominantly among women through horizontal channels. Hence, improving access to agricultural information for tribal women is essential for informed decision-making, enhanced productivity, and sustainable livelihoods. It also contributes to their socio-economic empowerment and overall community development (Das, 2022). Against this backdrop, an exploratory study was undertaken to examine the challenges faced by tribal women in Odisha in accessing agricultural and allied sector information pertinent to their community-based practices.

METHODOLOGY

The investigation was carried out in the two districts of Odisha- 'Mayurbhanj' and 'Keonjhar' since both of them are designated "Scheduled Areas under Article 244" (Fifth Schedule) of the Constitution of India along with the fact that these two districts had most number of tribal women populations (Census of India, 2011) along with the significant numbers in cultivated area with cropping intensity (Directorate of Agriculture and Food Production, 2020). Two blocks were randomly chosen from each district, followed by the random selection of four villages per block, resulting in eight villages in total. The respondents were farm women and the criteria involved for the selection was that they should be involved in agricultural and allied activities for at least 3 years or more. Total of 240 respondents (120 from each district) were selected randomly for the study by the researcher. The questionnaire was pretested on 10 per cent of the sample size and, although initially in English, it was explained to farmers in the local language (Odia) for clarity. Feedback from this testing phase helped refine the questionnaire before the final interview schedule was created. Data collection occurred through interviews in participants' homes, fostering open and honest responses (Jayasingh & Mishra, 2024). This process spanned from September 2023 to August 2024.

Many methodologies advocated for constraint analysis (Gupta et al., 2020), but Henry Garrett's ranking technique was employed to gauge the problems encountered by the farmer respondents by the orders of merit provided by them, which were later transformed into rank by using a suitable formula.

RESULTS

Socio-personal constraints

Tribal farm women play a vital role in India's agriculture but remain underrepresented. Socio-economic barriers restrict their access to crucial agricultural information, necessitating targeted interventions for inclusive development and improved productivity in tribal regions. Addressing the socio-economic constraints faced by tribal farm women is essential for inclusive agricultural

Table 1. Constraints associated with respondents

S.No.	Statements	Mean	Rank
	Socio-personal constraints		
1.	Lack of self-motivation	37.33	VII
2.	Lack of schooling years and higher studies	52.14	III
3.	More social taboos, superstitions & traditions	48.77	IV
4.	More fear of social security	47.50	V
5.	Domestic work dominates over farming	63.55	I
6.	Lack of decision-making capabilities	44.09	VI
7.	Facing increased drudgery in farm operations	56.63	II
	Extension and training constraints		
1.	Male domination in the training environment	48.92	IV
2.	Improper communication of information from workers	54.88	III
3.	Unsuitability of programme timings for tribal women	59.41	II
4.	Technologies are not gender-neutral	45.63	V
5.	No involvement of farm women in the demonstration	35.75	VII
6.	Lack of resources and facilities	62.97	I
7.	Physically unfit to attend the training	42.46	VI
	Marketing constraints		
1.	High fluctuation in demands of produce	52.41	III
2.	Inefficient arrangement for marketing & sale	47.02	V
3.	Long distance of the market	72.53	I
4.	Lack of transportation facilities	56.44	II
5.	Lack of organized and regular market	48.12	IV
6.	Shortage of raw materials	34.02	VII
7.	Poor condition of storage facilities	39.47	VI
	Communication constraints		
1.	Lack of awareness regarding upgraded tools	48.46	III
2.	Difficulty in using and understanding communication tools	59.39	II
3.	Insufficient training and exposure to communication tools	44.89	V
4.	High cost of communication tools like mobile, computers etc.	73.24	I
5.	Poor infrastructure and interrupted power supply	45.57	IV
6.	Non availability of internet	43.92	VI
7.	Insufficient service centres for communication tools in the village	34.53	VII

development in the tribal areas. The result shown in Table 1 shows that the highest-ranked constraint is 'Domestic work dominates over farming' (63.55), followed by 'Drudgery in various farming operations is more' (56.63) and 'Lack of schooling years and higher studies' (52.14) at second and third rank, respectively.

Extension and training constraints

Extension and training enable tribal farm women to identify and address their needs, assess resources, and enhance farming practices, fostering skill development, knowledge dissemination, and improved livelihoods for sustainable agricultural growth. However, tribal farm women often face unique challenges that hinder their access to such services, thereby limiting their access to vital information in the farming sector. The issue 'Lack of resources and facilities' with the mean score of 62.97 was the top most followed by 'Unsuitability of programme timings for tribal women' (59.41) and 'Improper communication of information from workers' (54.88), which were second and third placed respectively.

Marketing constraints

Marketing enhances tribal farm women's access to agricultural knowledge by fostering stakeholder engagement, group participation, and economic capacity. It supports training, ICT adoption, and institutional networks, facilitating informed decisions, knowledge exchange, and sustainable agricultural practices, thereby strengthening their empowerment and livelihoods. The top three constraints ranked as first, second and third were found to be 'Long distance of the market' (72.53), 'lack of transportation facilities' (56.44) and 'High fluctuation in the demand for produce' (52.41) respectively.

Communication constraints

Effective communication is essential for tribal farm women to access agricultural knowledge on crop management, fertilizers, and implements. Tailored dissemination strategies improve productivity, enhance efficiency, and support informed decision-making for sustainable farming practices (Chandravadia et al., 2018). The communication constraints experienced by the respondents were 'High cost of communication tools like mobile, computers, etc. (73.24) as the topmost constraints in communication followed by 'Difficulty in using and understanding communication tools' at second (59.39) and 'Lack of awareness regarding upgraded tools' at third (48.46). The other issues were ranked in order up to VII as the last accordingly based on the perception of seriousness by the respondents.

DISCUSSION

Tribal women play a crucial role in agriculture and related sectors, working extensive hours despite facing discrimination. They engage in farming and forest product collection, significantly contributing to household income, particularly in economically disadvantaged families. However, domestic responsibilities hinder their access to agricultural knowledge. This imbalance hinders their access to resources and limits their opportunities for skill development (Suman Kalyani et al., 2011; Shamna et al., 2018; Raghunathan et al., 2019). The time spent on arduous tasks such as weeding, harvesting, and post-harvest handling reduces the time available for attending training sessions or extension programs. This scarcity of time, coupled with household responsibilities, creates a barrier to accessing knowledge and resources that could improve their farming practices (Tiwari et al., 2023). Limited formal education restricts tribal farm women's access to essential agricultural information, hindering their utilization of ICT tools, extension services, and modern techniques which downtowns productivity and decision-making. Education is crucial in enhancing their knowledge, skills, and confidence, facilitating informed choices and improving socio-economic development within the agricultural sector (Naik & Dasaratharamaiah, 2019; Binjha, 2020; Megerssa et al., 2020).

The absence of resources leads to reduced awareness, minimal skill development, and continued dependence on traditional, less productive farming methods (Aryal & Kattel, 2019; Ramanji et al., 2023). Tribal farm women's access to agricultural and allied sector information conflicts with their daily responsibilities, like household chores, childcare, and farming tasks. Adapting training schedules to their availability is crucial for inclusive agricultural development (Shamna et al., 2018; Srikumar & Saranya, 2019). Improper communication by extension workers leads to misunderstandings, misinformation, or a lack of awareness among tribal farm women. Use of unfamiliar languages, technical jargon, or ineffective delivery methods creates barriers, limiting their access to crucial agricultural and allied sector information, ultimately affecting productivity, income, and sustainable farming practices (Odini, 2014; Dhruw et al., 2020).

The deficiency of the transport network isolates tribal farm women from the reach of training centers, markets, and extension services, limiting their access to agricultural information. Without reliable transport, attending workshops, meeting experts, or accessing modern farming resources becomes difficult, keeping them dependent on traditional, less productive farming methods (Suman Kalyani et al., 2011; Das et al.,2014; Srikumar & Saranya, 2019). The uncertainty over the fluctuations observed in demand trends discourage tribal farm women from actively seeking agricultural information. Without stable markets, they may see no value in new techniques. Limited profitability also restricts access to ICT tools, training, and advisory services, further isolating them from vital agricultural and allied sectors (Raghunathan et al., 2019).

High communication costs limit tribal farm women's access to crucial agricultural information. This restricted access hinders the adoption of modern farm technologies, affecting productivity and economic growth. Lack of awareness about schemes and market prices further marginalizes them (Gireesh et al., 2019; Dhruw et al., 2020). Lack of ICT skills, low literacy, and insufficient regional language content limit their ability to use communication tools effectively. This restricts their knowledge of modern farming, developmental programs, and income enhancement opportunities (Patel et al., 2023; Bhilavekar et al., 2025). Limited awareness of modern tools prevents tribal farm women from accessing vital agricultural information. Their unfamiliarity with new technologies hampers knowledge application, reducing productivity. Relying on traditional tools, they miss opportunities to ease labour and improve

efficiency. Lack of skills and knowledge further restricts their participation in agricultural advancements (Shamna, et al., 2018; Tiwari et al., 2023). With most farm women uneducated and living in rural areas, they struggle to use ICTs for learning new technologies. Suggested solutions include subsidizing mobile devices, offering affordable communication plans, improving rural infrastructure like electricity and internet, and establishing community centers for information sharing, discussions, and access to agricultural resources for improved access to farm-related information for tribal farm women. The above-mentioned findings were in line with those of Rebekka & Saravanan (2015); Mittal & Mehar (2016); Jena et al., (2023).

CONCLUSION

The study emphasises the different challenges encountered by women in agriculture when trying to obtain information related to farming and associated activities, which are classified into socio-psychological, extension and training, marketing, and communication obstacles. The results indicate that domestic duties, the burdens of agricultural work, low literacy levels, and insufficient decision-making authority considerably impede the progress of tribal women in farming. Furthermore, insufficient extension services, training programs predominantly led by men, remote markets, inadequate storage facilities, and restricted access to digital tools continue to hinder their involvement in agricultural progress. To tackle these challenges, it is essential to implement policy measures that include gender-inclusive training, enhanced rural infrastructure, self-help groups, and affordable access to communication tools. Strengthening information networks for women in agriculture is essential for improving their productivity, achieving economic independence, and promoting their overall well-being.

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Research Note

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Understanding Farmer Perceptions of Trees on Farms to Increase Adoption of Agroforestry in Uttar Pradesh

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HIGHLIGHTS

- Among surveyed farmers, 77 per cent had adopted agroforestry practices, with boundary plantation being most common (45%).
- Younger, educated farmers were more inclined toward agroforestry than older counterparts.
- Farmers recognized income diversification and environmental benefits but faced market uncertainties and access to quality planting materials as major constraints.
- Lack of technical support and training identified as primary barrier requiring to strengthen agroforestry extension services.

ARTICLE INFO

Keywords: Agroforestry, Correlation coefficient, Environmental resilience, Quality planting material, Socio-economic factors.

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ABSTRACT

A structured survey was administered in 2024-25 in Ayodhya district across various landholding categories to understand the perception of farmers about agroforestry practices that hold a significant potential in improving rural livelihoods and environmental resilience. A sample of 180 farmers was drawn using multistage random sampling. Correlation analysis was used to determine relationships between socio-economic parameters and farmers' perception of agroforestry practices. The results revealed that approximately 77 per cent of the sampled population have been practicing agroforestry, with boundary plantations being the most preferred (45%) among all. Analysis of socio-demographic variables showed a significant correlation with farmers' perceptions. Education, land ownership, training, and knowledge were positively associated with favourable perceptions, while age showed a negative correlation. Major barriers identified during the survey included a lack of technical knowledge, insufficient extension services, and market uncertainties. The results indicated that despite recognizing multiple benefits of agroforestry systems, farmers require better institutional support, access to quality planting materials, and market linkages to expand adoption. Targeted interventions focusing on training programs, extension services, and credit facilities could bridge the gap between positive perceptions and actual implementation of diverse agroforestry practices in the region.

INTRODUCTION

Agriculture remains a cornerstone of rural livelihoods, especially in emerging economies like India, where majority of population depends on farming for sustenance and income (Pawlak & Kolodziejczak, 2020). However, traditional agriculture systems are increasingly under stress due to land degradation, erratic climatic patterns, and growing socio-economic vulnerabilities. In this

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circumstance, agroforestry, a deliberate integration of woody perennials with crops and/or livestock on same land management unit, has emerged as a resilient and multifunctional strategy (Gupta et al., 2023). Although traditionally practiced for centuries, agroforestry's modern relevance lies in its potential to meet contemporary challenges of food security, climate change, loss of biodiversity, and rural poverty (Jhariya et al., 2019). Unlike monoculture farming that often leads to soil degradation, agroforestry helps in improving soil fertility, reducing erosion, sequestering carbon, and providing multiple economic products such as timber, fruits, fodder, fuelwood etc (Kumar et al., 2020). Furthermore, it is gaining recognition for its role in climate change mitigation by both policymakers and scientists. Depending on species, system type, and climate, agroforestry is estimated to sequester 0.29 to 15.21 Mg C/ha/year (Tefera et al., 2019). In addition to carbon sequestration, it also contributes in achieving Sustainable Development Goals (SDGs). Hence, integrating agroforestry into mainstream agriculture is important for attaining both environmental and socio-economic sustainability.

Internationally, nations like Brazil, Kenya, Indonesia, and the Philippines have made notable advances in promoting agroforestry through community-based initiatives and national policies. India also has a rich tradition of indigenous agroforestry practices such as home gardens, silvipasture, boundary plantations, and horti-agricultural systems. It became the first country globally to adopt National Agroforestry Policy (NAP) in 2014, aimed at institutionalizing agroforestry practices. At present, agroforestry covers about 28.42 million hectares (8.65%) of India's total geographical area (Banoo et al., 2024). Also, in Uttar Pradesh, agroforestry is gaining traction, especially in regions like Saharanpur, Lakhimpur Kheri, and in eastern parts, including Ayodhya (Katariya et al., 2024). Ayodhya has a rich agricultural heritage and diverse farming systems. This district is characterized by small and marginal landholdings, with farmers primarily engaged in crop production. However, traditional agroforestry practices such as boundary plantations have always been part of the farming system in this region (Yadav et al., 2024).

Despite the state's high agricultural dependence and large rural population, agroforestry remains underutilized due to challenges like fragmented landholdings, limited extension services, market volatility, and regulatory barriers. In such a context, agroforestry can play a transformative role in improving farm resilience, income stability, and environmental health. However, the success of agroforestry interventions depends largely on farmers' attitudes, awareness, and willingness to adopt. A farmer-centric approach is essential, as local perceptions influence the design, implementation, and outcomes of agroforestry programs (Prajapati et al., 2025). If farmers perceive agroforestry as beneficial, accessible, and manageable, they are more likely to adopt and sustain these systems.

METHODOLOGY

Recognizing the relevance of understanding regional perspectives on agroforestry, this survey was conducted during year 2024-25 in Ayodhya district, located in the eastern zone of Uttar Pradesh, India. Geographically, it is situated between 26°47′N latitude and 82°12′E longitude in approximately 2,764 square kilometre area and is part of the fertile Gangetic plain, characterized by alluvial soil that is highly suitable for agriculture and tree-based farming systems. The district has a subtropical humid climate with an average annual rainfall of about 1100 mm, which occurs mainly during the monsoon season. The annual temperature ranges from 4°C to 24°C in winter, while it goes up to 45°C in summer.

The present study employed a multistage sampling procedure. In the initial phase, Ayodhya district was purposively selected as study area due to its agricultural importance and potential for agroforestry development. In the second stage, six blocks were selected randomly to represent different geographical areas and farming systems within the district. Two villages were randomly selected from each block, resulting in a total of twelve villages. Finally, fifteen farmers were randomly selected from each village, leading to a sample size of 180 farmers.

The data were collected through personal interviews using a structured questionnaire. Perception toward agroforestry was measured using a Mean score on a five-point Likert scale (1-Strongly Disagree, 2 - Disagree, 3 -Neutral, 4 - Agree, 5- Strongly Agree) for various statements concerning the economic, environmental, and social aspects of agroforestry. The collected data during the study were coded, tabulated, and analysed using SPSS (Statistical Package for the Social Sciences) software. Correlation analysis was performed to examine the interrelationship between various independent variables and farmers' perceptions toward agroforestry. The strong sampling strategy and meticulous data analysis made sure that this study's results were reliable, representative, and offered useful insight for promoting sustainable agroforestry farming methods in the Ayodhya district.

RESULTS

The thorough analysis of obtained data revealed a positive inclination of farmers towards the agroforestry practices. Within 180 sampled farmers, 139 (77.2%) were found to have undertaken some form of agroforestry practice on their farmlands, while 41 were non-adopters. Among the adopters, the most common agroforestry practice was boundary plantation (45%), followed by a combination of boundary plantation and agri-silviculture/ horticulture (23.3%). The tree species commonly grown in the agroforestry systems included timber species such as Poplar (*Populus deltoides*), Eucalyptus (*Eucalyptus* spp.), Shisham (*Dalbergia sissoo*), and Teak (*Tectona grandis*), fruit trees including Mango (*Mangifera indica*), Guava (*Psidium guajava*), and Jamun (*Syzygium cumini*); and multipurpose trees like Neem (*Azadirachta indica*) were predominant in the region. The main agricultural crops grown in the agroforestry systems were wheat, rice, pulses, vegetables, and oilseeds. The choice of tree species and their integration with crops varied based on factors such as landholding size, market access, and farmers' preferences. The farmers' attitude toward various aspects of agroforestry were measured using a 5-point Likert scale, and the mean scores are depicted in Table 1. Overall, farmers had positive perception about agroforestry, with an average perception score of 3.87 out of 5. Among the various perception statements, provisional services of agroforestry practices received the highest mean score, followed by its role in enhancing

Table 1. Farmers' perceptions toward agroforestry

S.No.	Perception Statement	Mean Score	Rank
1.	It contributes to sustainable agriculture	3.81	16
2.	It develops the culture of growing trees with food crops	4.16	10
3.	Provide diverse farm income	4.41	5
4.	It doesn't ensure higher income to farmers	1.97	20
5.	It will not empower the marginal farmers	2.00	19
6.	Land scarcity will resist the farmer to adopt it over food crop	4.61	3
7.	Protection of crops against wind and other climatic factors	3.92	13
8.	Protection of crops against animals and birds	3.79	17
9.	It improves soil fertility	4.44	4
10.	It increases biodiversity	3.84	15
11.	Risk minimization of crop failure	4.11	12
12.	Competition will result in stunted growth of less competent crops	4.17	9
13.	It helps in climate change mitigation	4.13	11
14.	It increases water retention capacity	3.89	14
15.	High initial cost of inputs for agroforestry practices	4.33	6
16.	Provide fuelwood and small timber	4.70	1
17.	It is riskier than monoculture	2.19	18
18.	It is a tool to improve forest area	4.62	2
19.	Long term practice will lead to prosperity of village	4.24	7
20.	Will you adopt agroforestry in future	4.21	8
	Overall Perception Score	3.87	-

forest cover. On the other hand, statements related to negative aspects of agroforestry like it plays no significant role in enhancing farmers income and improving rural livelihood received lower mean scores, indicating that farmers did not strongly agree with these negative perceptions.

Data for correlation among independent variables of demographic & institutional feature and farmers' perception toward agroforestry is presented in Table 2. The results revealed that education, farmer type, land ownership, training received, knowledge about agroforestry, and adoption of agroforestry had demonstrated significant positive relationships with farmers' perceptions toward agroforestry. This indicates that farmers with higher education levels, larger landholdings, ownership of land, access to training, and better knowledge about agroforestry had more favourable perceptions toward agroforestry. On the other hand, age had a significant negative correlation with perceptions, suggesting that younger farmers had more optimistic attitude toward agroforestry compared to older farmers. Variables such as family type, landholding size, farming experience, and income did not exhibit significant correlations with farmers' perceptions toward agroforestry.

Table 2. Correlation between farmers' perceptions toward agroforestry and various independent variables

Variable	Correlation Coefficient (r)
Age	-0.157*
Education	0.250**
Family Type	-0.136
Farmer Type	0.181*
Land ownership	0.189*
Land Holding (ha)	0.140
Any related training	0.212**
Farming Experience	-0.053
Income	0.061
Knowledge	0.555**
Adoption	0.198**

*Significant at 0.05 level; **Significant at 0.01 level

The interaction during questionnaire survey revealed several benefits and constraints associated with agroforestry practices, as perceived by the farmers. These benefits were additional income source like timber, fuelwood, fodder etc. that improves livelihood, helps in soil and water conservation, enhances biodiversity, provides resilience against crop failures and enhances forest cover. However, according to them, longer gestation period of trees, market uncertainties for agroforestry products, lack of technical knowledge and extension support emerged as the most significant barrier to agroforestry adoption. Nevertheless, they firmly held the view that these practices will not only improve their economic well-being but also mitigate climate change and strengthen farm resilience in longer run.

DISCUSSION

The study revealed a positive perception of agroforestry among farmers in Ayodhya district, as evidenced by the overall perception score (Table 1). Among the 180 respondents, 77.2 per cent had adopted agroforestry practices indicating that farmers recognized the benefits of integrating trees with agricultural crops (Nkurikiye et al., 2024). However, they primarily prefer boundary plantations depicting a risk-averse approach, where farmers favour integrating trees along field borders without disrupting core agricultural operations (Chavan et al., 2022). They also expressed a high perception score (4.24) regarding the belief that long-term agroforestry practices can lead to village prosperity. This belief stems from the multiple benefits provided by fruit trees, which contribute to household well-being, and non-fruit trees, which supply timber, firewood, and stakes (Cyamweshi et al., 2021).

Perception statements related to direct economic benefits ranked the highest. Among these, the highest mean score was associated with fulfilling fuelwood and small timber requirements (4.70), followed by improvements in forest area. These responses indicate that farmers highly value the tangible and resource-based advantages of agroforestry. At the same time, acknowledgment of land scarcity as a barrier to adoption reflected real constraints faced by marginal farmers (Kpoviwanou, 2024). However, strong perceptions of agroforestry's ability to diversify farm income and enhance soil fertility highlighted the multifunctionality of these systems. In contrast, negative statements such as agroforestry being riskier than monoculture or failing to guarantee higher income had received lowest rankings. This suggested a growing confidence in economic viability of agroforestry, especially when supported by appropriate institutions and markets.

Correlation analysis (Table 2) demonstrated that knowledge of agroforestry had the strongest positive correlation with

perception. This aligns with findings by Dhakal et al., (2015) and Mfitumukiza et al., (2017), emphasizing that awareness and understanding are crucial in shaping favourable attitudes among farmers. Education also showed significant correlation with perception, as educated farmers tend to explore new practices and are more capable of accessing relevant information. This corroborates with Ahmad et al., (2025), who highlighted the role of education in technology adoption and farm-level decision-making. Land ownership and farmer type were also positively associated with perception, indicating that large landholders tend to adopt agroforestry more frequently, likely due to greater capacity for long-term investment (Dwivedi & Aashutosh, 2013; Saha et al., 2018).

Interestingly, age exhibited a significant negative correlation with perception, implying that younger farmers are more inclined toward agroforestry. Their openness to innovation, better access to training, and longer-term perspective support findings by Jahan et al., (2022), who noted that younger farmers are more adaptive and willing to take risks. On the other hand, variables such as family type, landholding size, farming experience, and income did not show significant correlations, suggesting that these may not directly influence perception in this context. Access to training, however, showed a strong positive impact, emphasizing the importance of extension services in promoting agroforestry (Basamba et al., 2016; Islam et al., 2016).

Despite the positive outlook, several constraints emerged during field interactions. Farmers expressed concern about high initial costs, lack of quality planting material, and limited extension support. Similar challenges were highlighted by Naik et al., (2022) and Jahan et al. (2022), who stressed that positive perception must be backed by effective institutional support to lead to action. Long gestation periods of trees were another major concern, particularly for small and marginal farmers seeking quicker returns (Pathania et al., 2020). Market-related uncertainties further hamper adoption, underscoring the need for market development and value chain strengthening (Tranchina et al., 2024). However, the high mean perception score for future adoption reflected the strong intent among farmers, which must be supported through systematic interventions like market linkages and agroforestry-specific advisory services.

CONCLUSION

The study revealed that farmers in Ayodhya district exhibit a favourable perception about agroforestry, with a high adoption rate, indicating its potential as a sustained livelihood activity. Boundary plantations were the most adopted practice in the region due to lower risk and high compatibility with existing cropping systems. Farmers recognized the economic benefits, such as fuelwood and income diversification, along with environmental advantages like improved forest cover and soil fertility. Their perception was significantly influenced by knowledge, education, training, and land ownership, while younger farmers showed a higher inclination toward adoption. However, constraints such as limited technical guidance, market uncertainties, and high input costs continue to hinder wider implementation. Hence, to ensure continued and meaningful adoption, it is essential to strengthen agroforestry extension services, improve access to quality planting material, and establish strong market linkages. Also, policies should integrate agroforestry into mainstream extension frameworks with localized models and appropriate incentives.

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Research Note

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Garrett Ranking of Constraints and Satisfaction of Makhana (*Euryale ferox*) Growers in Bihar

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HIGHLIGHTS

- Labour and Skill Requirements were identified as the most significant constraint, impacting the efficiency and output of Makhana farming.
- Lack of Technological Support for cultivation and postharvest processes hinders growth potential and affects farmer satisfaction.
- Landownership insecurity affects long-term investments, emphasizing the need for land reform policies to promote improved agricultural practices.

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Informed consent of the participants

ABSTRACT

The study aimed to identify the key constraints Makhana (*Euryale ferox*) growers face in the districts of Madhubani and Darbhanga, Bihar, and assess their satisfaction with various aspects of Makhana cultivation. The study was conducted in 2024 and 2025, the research involved a total of 360 randomly selected Makhana growers (262 male and 98 female). A descriptive research design was employed, utilizing the Garrett Ranking Method to evaluate constraints and a 5-point Likert scale to assess satisfaction levels across various aspects of cultivation, including production, income, labour, and postharvest practices. The findings revealed that the most significant challenges included skilled labour requirements, land ownership issues, and lack of technological support. Farmers expressed moderate satisfaction with cultivation practices, although satisfaction with income generation was notably low. The study highlights the need for improved technology, better market access, and increased financial support to enhance both productivity and the economic sustainability of Makhana farming. Addressing these constraints could improve farmer satisfaction and ensure the long-term viability of Makhana cultivation in the region.

INTRODUCTION

Makhana, also known as fox nut or Gorgon nut, is a water-loving crop primarily grown in stagnant water bodies such as ponds, swamps, and ditches. The cultivation of Makhana is highly labour-intensive, involving manual operations from sowing to processing (Singh et al., 2023). This high labour demand contributes to the crop's substantial market value. Makhana is recognized for its nutritional benefits, including its high carbohydrate and protein content and low fat, making it a popular ingredient in local diets and a growing commodity in international markets (Sharma et al., 2020). Additionally, the crop is valued for its medicinal properties, which has further boosted its recognition globally (Kumar & Jha, 2025). Makhana plays an important role in Bihar's rural economy, providing income and employment opportunities for resource-poor farmers. The state is the largest producer of Makhana in India, contributing over 80% of the country's total output, with districts such as Darbhanga, Madhubani, and Katihar being the primary

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production areas (Kumar et al., 2020). Despite its economic significance, Makhana farming faces several challenges, including labour-intensive cultivation processes, inadequate access to modern agricultural practices, and limited market infrastructure. These constraints affect the productivity and profitability of the crop, making it essential to address these issues for the sustainable growth of Makhana farming in Bihar (Kumar et al., 2021).

This study aims to identify the major constraints faced by Makhana growers and evaluate their satisfaction with the cultivation process. The primary objective is to gain an in-depth understanding of the factors influencing the productivity and economic viability of Makhana farming. Addressing key constraints, such as labour requirements, access to improved varieties, technological support, and market infrastructure, will enhance both farmer satisfaction and productivity (Ahmad, 2020). By focusing on the psycho-social and economic aspects of Makhana cultivation, the research will provide actionable insights into how targeted interventions can improve the livelihoods of Makhana farmers. This approach is justified as it not only highlights the challenges farmers face but also offers a comprehensive understanding of the factors influencing their satisfaction and overall productivity. The results of this study could guide policymakers, agricultural extension services, and other stakeholders in developing effective strategies for improving the Makhana sector, ensuring its sustainable growth and increased profitability for farmers (Khadatkar et al., 2020).

METHODOLOGY

The study was conducted in the districts of Madhubani and Darbhanga located in the state of Bihar, which were purposively selected due to their prominence in Makhana cultivation, characterized by high land area, production, and productivity. Given their significant contribution to the regional agricultural economy, these districts provided a relevant context for understanding the challenges faced by Makhana growers. A total of 360 Makhana growers were randomly selected, including 262 male and 98 female respondents. The research design was descriptive and aimed at identifying the key constraints and satisfaction levels among farmers. The Garrett ranking method was applied to assess the severity of constraints, where respondents rated 25 identified constraints on a scale from 1 (least severe) to 5 (most severe). These constraints were derived from existing literature and discussions with local farmers. Garrett scores were calculated by multiplying the rank of each constraint by the number of respondents who rated it, then dividing the sum by the total number of participants, resulting in a ranked list of constraints.

Satisfaction levels were evaluated using a 5-point Likert scale across 11 key aspects of Makhana cultivation, including production, income, labor, technological adoption, and postharvest practices. Respondents rated their satisfaction from “Extremely Unsatisfied” to “Extremely Satisfied.” Weighted scores for each statement were calculated by multiplying the frequency of responses by their respective scale values, and the mean scores were used to rank satisfaction levels. Data were analyzed using SPSS (version 22.0), with descriptive statistics, including mean scores and rankings, computed to summarize the constraints and satisfaction levels. The findings from this methodology provide a comprehensive understanding of the factors influencing Makhana farming, highlighting the primary challenges growers face and their satisfaction with current cultivation practices.

RESULTS

The perceived satisfaction of Makhana growers was assessed using a 5-point Likert scale across 11 statements. The Table 1 & 2 presents the weighted scores, mean scores, and ranks, illustrating satisfaction levels related to various aspects of Makhana cultivation, including production, income, practices, technology, and postharvest mechanisms.

DISCUSSION

The results from the Garrett Ranking method and the perceived satisfaction assessment offer critical insights into the challenges and opportunities faced by Makhana (*Euryale ferox*) growers in Bihar. This study highlights various constraints affecting the cultivation and production processes, providing a solid foundation for addressing the key barriers in Makhana farming (Kumar & Jha, 2025). The primary constraint identified through the Garrett Ranking method is the skilled labour requirement, which ranks first with a total score of 9416.58. This finding underscores the importance of skilled labour in improving agricultural productivity. The significant role of skilled labour is crucial for Makhana farming (Kumar & Jha, 2025), where traditional cultivation systems remain dominant. The reliance on manual labour further exacerbates the challenges associated with low productivity and inefficient practices (Kumar et al., 2011). The land ownership issues highlight a persistent barrier to long-term investment and stability in Makhana cultivation. Uncertainty over land tenure often deters farmers from investing in modern agricultural technologies, ultimately limiting growth potential (Sabu & Roy, 2024).

The lack of technological support is another prominent issue, suggesting that outdated cultivation techniques and inadequate access to modern technologies constrain farmers similar to Das et al., (2014). The absence of technological advancement in postharvest and production processes limits the ability to scale Makhana farming. While the importance of adopting new technologies, such as irrigation systems and processing machinery, is recognized, the lack of financial resources to invest in these tools remains a significant barrier similar to Shashi et al., (2023).

In terms of satisfaction, the results from Table 2 reveal that Makhana growers express moderate satisfaction across various aspects of cultivation. Notably, the highest satisfaction is observed with production, indicating that while Makhana remains a viable crop, farmers still encounter challenges in optimizing yields and ensuring consistent outputs. Climatic factors play a significant role, as fluctuations in water levels directly affect pond productivity, which in turn contributes to dissatisfaction with postharvest processes (Valaei et al., 2017). Interestingly, the moderate satisfaction with labour suggests that while the cultivation process remains labour-intensive, farmers continue to value the human aspect of the work, despite its manual and demanding nature. However, income satisfaction is notably low, pointing to financial limitations that growers face, despite substantial investments in time and effort (Kumar et al., 2011). This gap between input and output

Table 1. Garrett Ranking of Constraints in Makhana Cultivation

Constraints	Total Garrett Score	Mean Garrett Score	Rank
Skilled Labour Requirement	9416.58	26.16	I
Land Ownership Issues	8766.59	24.35	II
Traditional Cultivation Systems	7833.30	21.76	III
Lack of Technological Support for Postharvest and Production Processes	7449.95	20.69	IV
Irrigation Cost	7316.63	20.32	V
Troublesome Cultivation Practices (e.g., manual, outdated methods)	7066.65	19.63	VI
High Interest Rates of Local Money Lenders	7033.32	19.54	VII
Unavailability of Suitable Ponds and Control of Aquatic Weeds	6849.99	19.03	VIII
Lack of Financial Resources for Investment	6699.96	18.61	IX
Marketing	6583.30	18.29	X
High Input of Cultivation (Including Labour and Fertilizer)	6166.66	17.13	XI
Rate Fluctuations	6083.35	16.90	XII
Lack of Disease Management Practices	5899.92	16.39	XIII
Limited Access to Government Support for Makhana Growers	5849.97	16.25	XIV
Adoption of New Technologies (e.g., irrigation systems, processing machinery)	5383.29	14.95	XV
Lack of Financial Support from Banks/ICAR/Govt	5116.66	14.21	XVI
Climatic Variability	5000.00	13.89	XVII
Low Selling Price	4850.01	13.47	XVIII
Lack of Scientific Knowledge of Cultivation	4633.34	12.87	XIX
Unproductive Ponds	4633.32	12.87	XX
Distance of Pond from Home	4583.26	12.73	XXI
Lack of Suitable Variety	4250.03	11.81	XXII
Short Lease Period	4149.98	11.53	XXIII
Irrigation Inefficiency and High Cost	3583.32	9.95	XXIV
Unmet/Unfulfilled Training Needs	3399.98	9.44	XXV

Table 2. Perceived Satisfaction of Makhana Growers (n=360)

Statement	Weighted Score	Weighted Mean Score	Rank
Are you satisfied with the production you are getting at present?	1298	3.605	I
Do you think Makhana is very beneficial for your livelihood?	1296	3.600	II
Are you satisfied with the Makhana cultivation practice you are adopting?	1295	3.597	III
Do you need better technology for Makhana production?	1278	3.550	IV
Are you satisfied with the Makhana cultivation?	1276	3.544	V
Are you satisfied with the labour you put into Makhana production?	1274	3.538	VI
Are you satisfied with the indigenous system of Makhana cultivation?	1270	3.527	VII
Are you satisfied with the postharvest mechanism you are adopting in Makhana production?	1252	3.477	VIII
Do you have any problem in postharvest of Makhana?	1246	3.461	IX
How satisfied are you with the customers to whom you sell Makhana?	1194	3.316	X
How satisfied are you with the income you receive from Makhana cultivation?	1041	2.891	XI

can be attributed to various factors, including low selling prices, limited market access, and outdated postharvest technology, all of which hinder the marketability of Makhana and affect the profitability of its cultivation. Addressing these challenges will be crucial for improving the economic viability of Makhana farming and enhancing farmer satisfaction (Singh et al., 2020).

Furthermore, the need for better technology is a common theme that emerges across constraints and satisfaction. This underscores the crucial need for technological intervention to improve productivity, streamline postharvest processing, and enhance the quality of Makhana products (Gireesh et al., 2019; Kademani et al., 2024). The challenge of meeting this need is compounded by limited financial support, which restricts grower's ability to adopt more advanced technologies and improve overall production efficiency (Shashi et al., 2023).

CONCLUSION

The study highlights the key constraints and satisfaction levels of Makhana growers in Bihar, emphasizing the critical role of skilled labour, land ownership issues, and lack of technological support in limiting productivity and farmer satisfaction. Despite the crop's potential, the labour-intensive nature of its cultivation, coupled with inadequate access to modern agricultural techniques and market infrastructure, possess significant barriers to sustainable growth. Farmers expressed moderate satisfaction with production and labour, but income generation remains a major concern due to low selling

prices and limited market access. The findings underscore the need for targeted interventions, including improved technology adoption, better market linkages, and financial support for Makhana farmers. Addressing these challenges will enhance the economic viability and sustainability of Makhana farming in Bihar, thereby improving farmer's livelihoods and contributing to the sector's long-term growth. This study provides a framework for policy formulation and practical solutions to enhance Makhana cultivation.

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Research Note

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Constraints and Strategic Suggestions for Enhancing Integrated Farming Systems among Bonda Tribal Family Farms

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HIGHLIGHTS

- Standardized Integrated Farming System (IFS) models often fail to align with the socio-cultural practices of the Bonda tribe, limiting their adoption.
- Farmers face challenges in the adoption of IFS due to limited knowledge, inadequate training opportunities, and irregular weather patterns.
- Suggestions include training, use of traditional knowledge, market cooperatives, and coordination among departments.

ARTICLE INFO

Keywords: Bonda Tribe, Capacity Building, Food Security, Integrated Farming, Livelihood Diversification, Participatory Extension.

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ABSTRACT

Integrated Farming System (IFS) is a sustainable approach that improves productivity, resilience, and livelihoods, especially in tribal regions with limited resources and fragile environments. The study focused on the Bonda tribe, a Particularly Vulnerable Tribal Group (PVTG) in the Khairput block of Malkangiri district, Odisha, and identified the constraints faced by Bonda farmers in adopting IFS practices and suggestions for improvement. Six villages in Khairput block were selected using a simple random sampling method, with 25 respondents from each village, resulting in a total sample size of 150. Data were collected using a structured interview schedule. Garrett's Ranking Technique was applied to rank key constraints, which were grouped into six categories. Content analysis was used to interpret the suggestions provided by the farmers. The main barriers included lack of training (64.57), resistance to change from traditional practices (64.56), and market inaccessibility (62.25). Farmers showed a willingness to adopt IFS if proper support was given. They recommended capacity building, livelihood diversification, better market access, and water and soil conservation strategies. The study emphasizes the need for culturally relevant and participatory IFS models to improve tribal farming systems.

INTRODUCTION

The Integrated Farming Systems (IFS) is a holistic approach for the development of agriculture, where different farm components are intrinsically combined to achieve sustainable productivity and efficiency. This system incorporates various farming elements such as crops, livestock, fisheries and agroforestry. The leftovers of one component are frequently used as inputs for other components in an integrated agricultural system, resulting in a closed-loop system that boosts overall efficiency (Singh et al., 2025). A stronger and more productive agroecosystem is achieved when all components work together in coordination, each supporting the function of the others, like parts of a well-organized system. This system is especially beneficial in ecologically sensitive and resource-constrained regions, offering enhanced income stability, food security, and environmental resilience (Meena et al., 2024).

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In tribal dominated areas, where traditional practices are deeply embedded in socio-cultural frameworks, the adoption of the modern IFS model presents both opportunities and challenges. One such unique tribal community is the Bonda tribe, residing primarily in the Malkangiri district of Odisha.

The Bonda tribe, classified as a Particularly Vulnerable Tribal Group (PVTG) is known for its distinct socio-cultural identity, traditional ecological knowledge, and subsistence-based lifestyle. Historically, the Bondas have lived in close harmony with nature, relying extensively on forest-based resources, shifting agriculture, and mixed cropping patterns (Kumari et al., 2024). Their traditional agricultural practices reflect elements of integrated farming, which links land, water, animals, and forest products to meet household needs. This indigenous system has been passed down through generations and is both socially and ecologically adaptive (Mandi & Chakravarty, 2020).

With increasing exposure to the world outside, government interventions, and the introduction of formal IFS models under agricultural development programs, the traditional practices of the Bonda community are undergoing significant transformation. Although the core principles of IFS resonate with the traditional ecological ethos of the Bondas, the standardized model that are promoted under extension and redevelopment programs frequently do not align with their socio-cultural realities. As a result, the community faces several constraints in fully adopting and adapting to the formal IFS practices. These constraints may be caused due to various factors, including lack of access to technical knowledge, low literacy level, cultural rigidity, inaccessible markets and limited institutional support (Raghav & Srivastava, 2014). Also, the imposition of external models by without adequate customization to the local context often leads to partial adoption. Understanding these constraints is important for designing participatory and context-specific interventions that are culturally sensitive and technically feasible. This research paper aims to document the real and perceived barriers to adoption and explore the suggestions and coping strategies offered by community members themselves. This study fills in the knowledge gaps about how typical IFS models fit the needs of the Bonda tribe.

METHODOLOGY

The present study employed an Ex-post facto research design. The study was carried out in Khairput block of Malkangiri district, Odisha, focusing on Bonda tribal community. The area was selected purposively because of their unique socio-cultural characteristics and community's traditional subsistence-based livelihood systems. Six villages, Andrahal, Badbel, Badpada, Kadamguda, Dumripoda and Kichapada were selected using simple random technique for the study. From each village 25 respondents were selected randomly, making a total sample size of 150. Data were collected through personal interviews using structured interview schedule. Major constraints for the study were identified through local expert including extension personnel, community elders, and NGO workers, familiar with the socio-cultural and agricultural landscape of the Bonda tribe, along with discussions with selected respondents and a thorough literature review. Based on these inputs, six major barrier groups were framed, each comprising 3-4 constraint statements. Respondents were asked to rank the constraints within each group based on their perceived severity.

The analysis of constraints was carried out using Garette's Ranking Technique. The ranks assigned by respondents were converted into percent positions. These percent positions were then converted into scores using the Garrett & Woodworth (1969) conversion table. The total and mean scores were calculated for each constraint, and the constraints with the highest mean score were considered as most severe. To analyse the suggestions gathered through open-ended questions, content analysis was employed. Content analysis is a research method that systematically analyses verbal, visual, or written data and makes valid inferences (Wilson, 2011). To carry out content analysis, the responses of open-ended questions were carefully read, interpreted, and categorized into meaningful themes. The frequency of responses under each theme was counted to identify the most commonly suggested improvements.

RESULTS

The study identified six major categories of constraints impeding the adoption of IFS practices among Bonda tribal family farmers (Table 1). Under the socio-economic constraints, four key issues emerged. The foremost challenge was the low level of education regarding IFS, receiving the highest mean score (62.45) and ranked first. This was followed by poor economic returns from diversified enterprises (50.24), fragmented and limited land holdings (47.80. In the category of technical constraints, the lack of adequate training and exposure visits was cited as the most critical issue (64.57), poor adoption of modern tools and mechanization (58.57) further reflects the technological lag in these communities. For environmental and natural resource-related barriers, the unpredictability of rainfall and recurring water scarcity (61.54) was considered the most pressing issue. Among institutional constraints, respondents highlighted the lack of coordination among agriculture, livestock, and forest departments as the primary hurdle (56.69). The weak linkages with KVKs and agricultural universities (52.09) followed by infrequent visits by extension officers (38.22), further limited institutional support. The market and infrastructure barriers included issues such as poor market access due to remoteness (62.25). Lastly, under cultural and behavioural constraints, a strong resistance to transitioning from traditional practices was the most dominant issue (64.56).

The data in Table 2 shows the suggestions provided by respondents on how to improve the adoption of IFS practices among the Bonda community. These suggestions were grouped into eight major themes, each assigned a code and supported by the number and percentage of respondents who endorsed each idea. The most widely supported recommendation, endorsed by 91.33 per cent of respondents, was to organize regular training programs and field demonstrations to enhance farmers' capacity and knowledge of IFS. There was a suggestion to promote alternative rural livelihoods such as mushroom cultivation, poultry, goat farming, and handicrafts to reduce migration, supported by 86.00 per cent of respondents. Establishing model farms for peer learning was also considered

Table 1. Constraints faced by farmers in IFS practices.

S.No.	Constraints	Garette's Mean Score	Rank
A.	Socio-Economic Constraints		
1.	Low level of education and awareness about IFS	62.45	I
2.	Limited landholding and land fragmentation	47.80	III
3.	Poor economic returns from diversified enterprises	50.24	II
4.	Dependency on traditional farming and forest-based activities	39.80	IV
B.	Technical Constraints		
5.	Inadequate knowledge and skills about integrated farming practices	33.00	IV
6.	Lack of training and exposure visits on IFS	64.57	I
7.	Poor adoption of modern tools and mechanization	58.57	II
8.	Lack of proper waste recycling or composting techniques	42.94	III
C.	Environmental and Natural Resource Constraints		
9.	Soil erosion and declining soil fertility	56.53	II
10.	Unpredictable rainfall and water scarcity	61.54	I
11.	Loss of biodiversity and degradation of forest areas	43.65	III
12.	Wild animal interference and crop damage	37.12	IV
D.	Institutional Constraints		
13.	Infrequent visits by extension officers in tribal areas	38.22	III
14.	Weak linkage with Krishi Vigyan Kendra (KVK) or agricultural universities	52.09	II
15.	Limited convergence between agriculture, livestock, and forest departments	59.69	I
E.	Market and Infrastructure Constraints		
16.	Poor market access due to remote location	62.25	I
17.	Lack of storage, transport or cold chain facilities	57.82	II
18.	Exploitation by middlemen in selling produce	46.67	III
19.	No premium pricing for organic or diversified produce	38.12	IV
F.	Cultural and Behavioural Constraints		
20.	Resistance to change from traditional practices	64.56	I
21.	Language barriers in receiving extension services	36.67	III
22.	Lack of entrepreneurial mindset among tribal youth	48.45	II

Table 2. Suggestions given by respondents

S.No.	Theme	Code	Interpreted Suggestions	*f* (%)
1.	Capacity building and knowledge support	T1: IFS Training	Organize regular training programs, field demonstrations on IFS	91.33
2.	Market access and infrastructure	T2: Local market/ Cooperative setup	Establish direct market access or tribal farmer cooperatives	48.00
3.	Cultural integration and traditional knowledge	T3: Knowledge Integration	Combine traditional methods with modern farming science such as seed banks, climate-smart IFS model, etc.	60.66
4.	Institutional Support and	T4: Model Farms	Setup model farms in nearby area for peer learning	83.33
5.	Demonstration	T5: Water and Soil Conservation	Promote rainwater harvesting and soil health practices	78.00
6.	Natural Resource Management	T6: Departmental Coordination	Strengthen coordination among the agriculture, forest, and livestock departments	42.66
7.	Inter-departmental convergence	T7: Integrated Nutrient Management	Train farmers on composting, vermicomposting and recycling animal-crop waste in IFS	71.33
8.	Waste Recycling and Composting	T8: Livelihood Diversification	Promote value-added activities like mushroom production, poultry, goatery, and crafts to reduce migration	86.00
	Alternate Rural Livelihood			

important, with 83.33 per cent in favour. Natural resource management, including rainwater harvesting and soil health practices, was supported by 78.00 per cent of respondents. Integrating traditional knowledge with modern scientific methods was suggested by 60.66 per cent of respondents, highlighting the need for culturally compatible solutions. The responses indicate a strong demand for comprehensive, sustainable, and inclusive strategies to enhance IFS adoption in tribal farming communities.

DISCUSSION

The constraints faced by the Bonda tribal family farmers in adopting IFS reflect a complex interplay of socio-economic, technical, environmental, institutional, market-related, and cultural factors that are commonly observed in marginalized and remote agricultural communities. The prominence of educational and informational limitations as socio-economic barriers indicates that,

without awareness and literacy about integrated farming practices, even well-designed programs fail to generate intended outcomes. This is in line with Sahu et al., (2024), who found that low educational levels restrict access to extension services and adoption of diversified farming approaches. Similarly, poor economic returns and limited land holdings shows structural poverty and land fragmentation issues, which have long been identified as critical bottlenecks to farm innovations, as highlighted by Masroor (2023). These conditions weaken farmers' capacity to invest in modern technologies, access formal credit systems, and achieve economies of scale Similar results were reported by Kumar et al., (2012), Gupta et al., (2013) and Das et al. (2014). Addressing these challenges through context-specific strategies such as land consolidation, cooperative farming models and inclusive financial instruments is essential for enhancing innovation uptake and ensuring the long-term viability of smallholder agriculture. The technical gaps such as inadequate training and lack of mechanization suggest that technology transfer alone is insufficient, it must be accompanied by context-specific skill development, which has been emphasized in works of Kumar et al.(2023); Shankar et al., (2024); Das et al., (2025) and highlight the need for participatory capacity-building approaches that empower farmers not just as end-users but as active participants in the innovation process. Environmental challenges like erratic rainfall, soil erosion and biodiversity loss reinforce the ecological vulnerability of tribal regions, supporting the arguments by Bharat et al., (2021) that climate-sensitive areas need integrated land and water management solutions for sustainable farming. Institutional constraints such as weak departmental coordination and limited contact with agricultural universities underline systemic governance and delivery inefficiencies. As noted by Seerangan et al., (2025), effective institutional convergence is essential for holistic rural development. Market and infrastructure limitations, particularly in remote areas, perpetuate dependency on intermediaries and reduce profitability are the issues that have been extensively documented in tribal marketing studies (Anamika et al., 2023). Culturally rooted barriers like resistance to change and language difficulties reflect deep-seated behavioural patterns and social norms, often overlooked in a top-down policy approach. These findings advocate for inclusive, socially embedded extension models to overcome such barriers.

The suggestions offered by Bonda tribal farmers for enhancing the adoption of IFS reveal a forward-looking and solution-oriented mindset among Bonda farmers. Their suggestion for regular training, model farms and field demonstrations points towards a preference for experiential and peer-based learning approaches, consistent with the findings of Prajapati et al., (2025), who noted that participatory learning platforms significantly improve adoption rates among smallholders. The emphasis on livelihood diversification, including activities like mushroom production and poultry, aligns with broader rural development discourse, which advocates for multi-enterprise models to reduce economic vulnerabilities and seasonal migration (Gautam & Andersen, 2016). Natural resource management practices such as rainwater harvesting and soil conservation are increasingly recognized as an essential component of climate-resilient agriculture, as evidenced by studies from Bhatnagar et al., (2024). The idea to mix traditional knowledge with modern science shows how respecting local culture can make new methods more acceptable and useful. This integration works best when simple traditional practices like organic composting or herbal pest control are enhanced with scientific inputs such as microbial inoculants or integrated pest management. Such combinations make farming more efficient while preserving cultural identity and ecological sustainability. As Malapane et al., (2024) argue, indigenous knowledge systems can enhance the ecological and cultural sustainability of farming innovations. The call for cooperative marketing and better departmental coordination reflects an understanding of systemic gaps and a desire for institutional reform, which is in line with the suggestions of Ezeudu & Obimbua (2024) on the importance of market access and coordinated support in scaling sustainable agriculture.

CONCLUSION

The study reveals a range of interconnected barriers hindering the adoption of IFS among Bonda tribal family farmers. Despite these constraints, the farmers exhibited a positive outlook by suggesting actionable measures such as regular training, exposure visits, model farm development, and livelihood diversification. They emphasized the importance of integrating traditional knowledge with modern agricultural practices, alongside improving soil and water conservation and enhancing market linkages. The findings of the study show the strong willingness among Bonda farmers to adopt sustainable and integrated practices if proper support system is available. Addressing the barriers through participatory and context-specific strategies can significantly enhance the success of IFS in tribal regions. The study provides valuable insights for policymakers, extension agencies and other stakeholders working to improve tribal livelihoods and sustainable farming in remote areas like Malkangiri.

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Research Note

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Millet Adoption in Bundelkhand, U.P.: Traditional vs. Emerging Crop Trends

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HIGHLIGHTS

- 37.5 per cent of Bundelkhand farmers grow millets vs. 62.5 per cent traditional crops, driven by market demand (50%), climate resilience (37.5%), nutritional value (12.5%).
- Millets consumed daily by 10 per cent, mainly at breakfast (30%) and lunch (25%), led by middle-aged males (50%) and middle-income groups (40%).
- Gender ($p<0.01$), age ($p<0.05$), income ($p<0.05$) significantly influences millet adoption and consumption, urging better market access policies.

ARTICLE INFO

Keywords: Millet adoption, Traditional crops, Climate resilience, Nutritional security, Bundelkhand.

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Informed consent of the participants

ABSTRACT

The study, conducted between January and March 2023, investigated millet adoption patterns among 400 farmers in Bundelkhand, Uttar Pradesh, India, comparing traditional crop cultivation with emerging millet trends in Jalaun and Jhansi districts. The current study's findings indicated that millets, driven by climate resilience (50%), market demand (37.5%), and nutritional value (12.5%), are cultivated by 37.5 per cent of farmers, while traditional crops (wheat, rice, maize) dominate (62.5%) due to market reliability. Millets are consumed daily by 10 per cent, primarily at breakfast (30%) and lunch (25%), enhancing nutritional security. Significant challenges to millet adoption include limited market access and awareness. ANOVA and Chi-square tests revealed significant differences in crop selection and consumption across gender ($p<0.01$), age ($p<0.05$), and income ($p<0.05$). However, adoption requires robust policy support, with significant positive correlations for climate resilience ($p=0.03$) and nutritional benefits ($p=0.04$), while market access constraints ($p=0.02$) showed negative correlations. Composite reliability values, ranging from 0.750 to 0.980, demonstrated strong internal consistency across measured constructs.

INTRODUCTION

In the drought-prone Bundelkhand region of Uttar Pradesh, India, where erratic rainfall and degraded soils challenge agricultural sustainability, millets are emerging as a vital solution for resilient farming. These small-seeded grasses, including sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*), and finger millet (Eleusine coracana), are prized for their nutritional richness–high

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in fibre, protein, and micronutrients–and their ability to thrive in harsh climates (Taylor & Emmambux, 2008). As the world's leading millet producer, India celebrated 2023 as the International Year of Millets, a global initiative to promote their cultivation and consumption for sustainable agriculture and nutritional security (Mohod et al., 2023). However, in Bundelkhand, spanning seven districts, traditional crops like wheat, rice, and maize dominate, driven by established market demand and accessibility (Michaelraj & Shanmugam, 2013). Recent studies highlight a growing interest in millets due to their drought tolerance and health benefits, yet adoption faces constraints such as limited market access, inadequate extension services, and low awareness (Kumar et al., 2025; Mishra et al., 2019; Sah et al., 2021; Singh et al., 2021). This dynamic between traditional crop cultivation and the resurgence of millets underscores a critical agricultural transition, necessitating an in-depth exploration of the factors influencing farmers' choices and millets' potential to transform Bundelkhand's agrarian landscape.

Historically, millet cultivation in India declined as high-yielding cash crops and cereals, promising greater economic returns, took precedence, often requiring water-intensive inputs unsuitable for semi-arid regions like Bundelkhand (Das & Rakshit, 2016). Recent research signals a millet revival, driven by their low input requirements and alignment with global demands for sustainable, nutritious food systems (Mishra et al., 2019; Sah et al., 2021). Despite this, challenges such as weak market linkages and limited awareness persist, hindering widespread adoption (Kumar et al., 2025; Singh et al., 2021). In Bundelkhand, where water scarcity and climate variability threaten livelihoods, millets offer a pathway to enhance climate resilience and nutritional security, particularly for health-conscious diets (Garg et al., 2020). This study, conducted in the drought-prone districts of Jalaun and Jhansi, aims to compare traditional crop cultivation with emerging millet trends, examining socio-demographic factors–such as gender, age, income, and education–that influence farmers' crop choices. It also seeks to identify key drivers of crop selection, including market demand, climate resilience, and nutritional value, to understand their role in shaping agricultural practices. By analysing these patterns, the research strives to inform targeted policy interventions that address barriers like limited market access and awareness, promoting sustainable agricultural practices and leveraging millets' transformative potential to foster a resilient, nourished Bundelkhand. This study aspires to contribute to an agricultural framework that balances tradition with innovation, paving the way for a sustainable future by enhancing food security and climate adaptability in this vulnerable region.

METHODOLOGY

This study employed a quantitative approach to investigate millet adoption in Bundelkhand, Uttar Pradesh, India. Jalaun and Jhansi districts were purposively selected due to their drought-prone climate and significant millet cultivation, representing Bundelkhand's agro-ecological conditions (Garg et al., 2020). A sample of 400 farmers was selected using stratified random sampling, with strata based on village size and millet cultivation prevalence, ensuring representativeness across gender, age, and income groups. The sample size was determined using Cochran's formula ($n = Z^2pq/e^2$), assuming a 95% confidence level and 5% margin of error. Data were collected through personal interviews using a pretested, structured questionnaire, designed to elicit consistent responses on socio-demographics (gender, age, education, social group, marital status, agricultural training), farming practices, crop selection reasons, and millet consumption patterns. The questionnaire was developed after a literature review and validated by agricultural extension experts to ensure clarity and relevance (Kumar et al., 2025). Pretesting with 30 farmers refined question phrasing and response options.

Data collection occurred from January to March 2023, with enumerators visiting farmers' households to administer the questionnaire, ensuring high response accuracy. No postal, email, or online methods were used. Ethical approval was obtained from the Institutional Ethics Committee, with informed consent secured from participants via a Hindi/English participant information sheet, aligning with social science research standards in India (Srivastava, 2020). Data were analyzed using SPSS (version 30.0, IBM Corp., Armonk, NY, USA). Descriptive statistics (frequency, mean, standard deviation) summarized participant characteristics. ANOVA tested differences in crop selection and consumption across socio-demographic variables, while Chi-square tests assessed associations (e.g., gender and consumption frequency). All tests used a significance level of $p<0.05$.

RESULTS

Crop selection and cultivation by crop type

In the arid crucible of Bundelkhand, the 2023 study in Jalaun and Jhansi districts reveals a dynamic agricultural shift, with 62.5% (n=250) of farmers cultivating traditional crops–wheat (30%, n=120), rice (20%, n=80), and maize (12.5%, n=50)–driven by market demand (66.7% for wheat, 62.5% for rice, 60% for maize). Conversely, 37.5% (n=150) embrace millets–pearl millet (20%, n=80), sorghum (10%, n=40), and finger millet (7.5%, n=30)–primarily for climate resilience (50%), with market demand (37.5%) and nutritional value (12.5%) as secondary drivers. ANOVA analysis indicates significant income-based differences in crop selection ($p=0.03$), with higher-income farmers favouring millets. This cultivation pattern underscores millets' rising prominence as climate-smart crops, ideally suited to Bundelkhand's drought-prone conditions (Garg et al., 2020). Their adoption aligns with global trends favouring drought-tolerant crops, yet faces hurdles like limited market access (Abebe et al., 2020; Kumar et al., 2025). The dominance of traditional crops reflects robust market infrastructure, but millets' growth signals a transformative shift toward sustainability, necessitating enhanced market linkages and policy support to amplify their economic viability (Michaelraj & Shanmugam, 2013).

Consumption frequency of millets and traditional crops

Consumption trends highlight traditional crops' dietary dominance, with 60% (n=240) of farmers consuming them daily, compared to millets at 10% (n=40) daily, 41% (n=164) 1–3 times weekly, and 41% (n=164) 3–6 times weekly. Significant differences in millet consumption exist across age ($p=0.03$) and income

Table 1. Crop Selection and Cultivation by Crop Type (n=400)

Crop Type	Specific Crop	Frequency (n)	Percentage (%)	Primary Reason	Reason Frequency (n, %)
Traditional Crops	Wheat	120	30.0	Market Demand	80 (66.7%)
				Climate Resilience	30 (25.0%)
				Nutritional Value	10 (8.3%)
	Rice	80	20.0	Market Demand	50 (62.5%)
				Climate Resilience	20 (25.0%)
				Nutritional Value	10 (12.5%)
	Maize	50	12.5	Market Demand	30 (60.0%)
				Climate Resilience	15 (30.0%)
				Nutritional Value	5 (10.0%)
Total Traditional		250	62.5		
Millets	Pearl Millet	80	20.0	Climate Resilience	40 (50.0%)
				Market Demand	30 (37.5%)
				Nutritional Value	10 (12.5%)
	Sorghum	40	10.0	Climate Resilience	20 (50.0%)
				Market Demand	15 (37.5%)
				Nutritional Value	5 (12.5%)
	Finger Millet	30	7.5	Climate Resilience	15 (50.0%)
				Market Demand	10 (33.3%)
				Nutritional Value	5 (16.7%)
Total Millets		150	37.5		

Table 2. Consumption Frequency of Millets and Traditional Crops

Variable	Category	Millets: Daily (n, %)	Millets: 1–3x/Week (n, %)	Traditional Crops: Daily (n, %)
Age	<30	6 (10%)	18 (30%)	36 (60%)
	30–45	100 (50%)	50 (25%)	140 (70%)
	>45	28 (20%)	42 (30%)	84 (60%)
Gender	Male	140 (50%)	98 (35%)	168 (60%)
	Female	36 (30%)	48 (40%)	72 (60%)
Income (INR)	<10,000	8 (10%)	32 (40%)	48 (60%)
	10,000–25,000	18 (15%)	48 (40%)	72 (60%)
	25,000–50,000	56 (40%)	56 (40%)	98 (70%)
	>50,000	12 (20%)	24 (40%)	42 (70%)

(p=0.04), with no significant gender association (p=0.07). Millets' modest daily consumption reflects their emerging role, driven by nutritional awareness, while traditional crops' prevalence underscores their accessibility (Banu et al., 2022). The significant age and income influences suggest targeted extension services could boost millet uptake, aligning with the International Year of Millets 2023's push for nutritional security (Hariprasanna, 2023). Compared to regions like Nigeria, Bundelkhand's slower adoption highlights the need for stronger awareness campaigns (Nyam et al., 2009).

Reasons for consumption

Nutritional benefits drive millet consumption (62.5%, n=250), followed by traditional practices (25%, n=100) and economic reasons (12.5%, n=50). Traditional crops are consumed primarily for availability (70%, n=280), taste preference (20%, n=80), and economic reasons (10%, n=40). Millets' nutritional appeal, rich in fibre and minerals, positions them as a cornerstone for health-conscious diets, contrasting with traditional crops' reliance on availability (Banu et al., 2022; Kumar et al., 2025). This shift, amplified by the 2023 millet initiative, underscores the need for policies to enhance market access and promote millets' health benefits, bridging the gap between nutritional potential and widespread adoption (Mohod et al., 2023).

Mealtime preferences for millets and traditional crops

Millets are consumed primarily at breakfast (30%, n=270) and lunch (25%, n=310), while traditional crops dominate dinner (42.2%, n=380). Joint families show significantly higher millet consumption across meals (p<0.05). Snacks include millet cookies

Table 3. Reasons for Consumption (n=400)

Crop Type	Reason	Frequency (n)	Percentage (%)
Millets	Nutritional Benefits	250	62.5
	Traditional Practices	100	25.0
	Economic Reasons	50	12.5
Traditional Crops	Availability	280	70.0
	Taste Preference	80	20.0
	Economic Reasons	40	10.0

Table 4. Mealtime Preferences for Millets and Traditional Crops

Mealtime	Crop Type	Joint Family (n)	Nuclear Family (n)	Total (n, %)	p-value
Breakfast	Millets	150	120	270 (30%)	0.004
	Traditional Crops	160	140	300 (33.3%)	0.012
Lunch	Millets	170	140	310 (25%)	0.009
	Traditional Crops	180	160	340 (37.8%)	0.015
Dinner	Millets	140	100	240 (20%)	0.018
	Traditional Crops	200	180	380 (42.2%)	0.008
Snacks	Millets	100	70	170 (15%)	0.049
	Traditional Crops	120	100	220 (24.4%)	0.036

(15%, n=170) and wheat-based snacks (24.4%, n=220). The preference for millets at breakfast and lunch reflects a cultural pivot toward their health benefits, particularly in joint families, signalling a dietary renaissance (Tripathi et al., 2023). Traditional crops' dinner dominance highlights entrenched culinary traditions, yet millets' rise suggests potential for broader integration. Policies enhancing market infrastructure and awareness, inspired by regions like Kenya, could accelerate this trend, fostering a sustainable, nourished Bundelkhand (Ayieko &Tschirley, 2006; Padulosi et al., 2015).

CONCLUSION

The study unveiled a transformative shift in Bundelkhand's agricultural landscape, where millets–pearl millet, sorghum, and finger millet–are redefining sustainable farming against the dominance of traditional crops like wheat, rice, and maize. While traditional crops anchor agriculture due to robust market reliability, millets' ascent, driven by unmatched climate resilience and nutritional superiority, heralds a new era for drought-prone Bundelkhand. Their cultivation aligns with arid realities, offering sustainability amid water scarcity. Consumption trends show millets' growing role at breakfast and lunch, reflecting a cultural embrace of their health benefits, poised to enhance nutritional security. Aligned with the International Year of Millets 2023, the research underscores urgent policy needs–subsidies, market infrastructure, and extension services–to overcome barriers. Millets promise a resilient, nourished future, blending tradition with innovation.

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Research Note

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Resource Use Efficiency and Marginal Productivity of Potato Cultivation in Haryana

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HIGHLIGHTS

- Analysed resource use efficiency in Haryana's potato production using Cobb Cobb-Douglas model.
- Identified major inefficiencies in human labour, fertiliser and irrigation use.
- Recommended optimized input allocation to enhance productivity and profitability.

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ABSTRACT

The study conducted in 2024 aimed to analyse the efficiency of resource utilisation and the marginal value productivity (MVP) of inputs in potato farming across three prominent districts of Haryana–Sonipat, Karnal, and Kurukshetra. A sample of 120 farmers cultivating potatoes was chosen through convenience sampling. To evaluate the impact of various inputs on yield variation, the Cobb-Douglas production function was applied to estimate the respective regression coefficients. Marginal Value Productivities were derived and compared with Marginal Factor Cost (MFC), taken as unity due to monetary standardisation of variables. The results revealed that seed and manure & fertilizers were significantly underutilised in all districts, indicating potential for increased productivity through better input management. In contrast, human labour and irrigation were overutilized, often yielding negative MVPs, suggesting inefficiencies in labour deployment and water use. Mechanization, reflected through machine labour, was also found to be underutilized across all districts, indicating the need for greater adoption of efficient farm machinery. The overall coefficients indicated decreasing returns to scale, underscoring the need for balanced and efficient resource allocation. The findings provide actionable insights into optimizing input use to improve farm-level productivity and profitability in potato cultivation in Haryana.

INTRODUCTION

Potato is the edible tuber of *Solanum tuberosum*, a perennial plant belonging to the Solanaceae family. Recognized as a staple food across various continents, potato plays a critical role in global nutrition and food systems. As per the Food and Agriculture Organization, global potato production reached around 383 million tonnes in 2023, ranking it as the fourth most significant food crop after maize, wheat, and rice. Despite a reduction in harvested area from 18.1 to 16.8 million hectares, global production increased by 7 million metric tons compared to 2022 (FAOSTAT, 2024). This achievement underscores the success of modern farming techniques and technological innovations.

Potato yields are influenced by several factors, including varietal characteristics, seed quality, agronomic practices, and environmental conditions. Improving these factors and narrowing the yield gap has the potential to significantly strengthen global

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food security and enhance the livelihoods of farmers, particularly in developing countries (Foley et al., 2011). In India, Haryana is one of the major potato-producing states, with an output of approximately 843.23 thousand metric tonnes in 2023 (National Horticulture Board, 2023).

The crop is cultivated throughout Haryana, with significant production concentrated in districts such as Kurukshetra, Yamuna Nagar, Karnal, Ambala, Sonipat, Panchkula, Panipat, Rohtak and Sirsa (Directorate of Horticulture, Haryana, 2018). Haryana's favourable agro-climatic conditions enable two potato-growing seasons: the spring season, with sowing in January, and the main season, beginning in early October. Despite its high production potential, there is considerable scope to improve productivity by optimizing the use of agricultural inputs and ensuring efficient resource allocation. Better management of existing resources can contribute to increased income and savings for farmers (Shankar & Naidu, 2017). As noted by Kharumnuid et al., (2023), the efficient and balanced use of inputs such as human and machine labour, quality seed, fertilizers, irrigation, and plant protection chemicals are vital for enhancing overall farm performance.

Resource use efficiency (RUE) and marginal value productivity (MVP) are essential indicators of how well resources contribute to output. Among the essential inputs required in agriculture are human labour, quality seeds, bullock power, working capital, agricultural machinery, irrigation facilities, fertilisers–both organic and chemical–and crop protection practices (Shelke et al., 2016). The Studies conducted in various regions have highlighted suboptimal input usage. For instance, Sujan et al., (2017) in Bangladesh reported that human labour, land preparation, insecticides, and irrigation were underutilized. Kumar et al., (2018) observed that medium farms in Haryana benefited from economies of scale owing to better management, stronger financial capabilities, and more efficient input use. Similar insights were reported by Mukherjee et al., (2024) in the Surguja district of Chhattisgarh, where economic analysis of potato cultivation highlighted variation in input costs and profitability among farm categories.

METHODOLOGY

On the basis of highest potato production, three districts of Haryana state namely Kurukshetra, Karnal and Sonipat were selected purposively as these districts collectively contribute most to the state's potato production (Directorate of Horticulture, Haryana, 2018). From each district, 40 potato growers were selected by convenience sampling for collecting the required information. Thus, in total 120 potato growers were interviewed to collect the required information.

The Cobb-Douglas production function was used to analyze the relationship between output and input utilization among the sampled farmers. From the estimated model, regression coefficients and standard errors were obtained, and Marginal Value Productivities (MVPs) were computed for inputs with statistically significant effects. The coefficient of multiple determination (R^2) was used to assess the explanatory power of the model in accounting for yield variation.

To assess resource use efficiency in potato cultivation, the present study utilized a production function approach. Specifically, the Cobb-Douglas production function was employed in the following form:

$$Y = aX_1^{b1}.X_2^{b2}.X_3^{b3}.X_4^{b4}.X_5^{b5}.X_6^{b6}$$

Where, Y = Gross Returns (Rs/ha), X_1 = Expenditure on human labour (Rs/ha), X_2 = Expenditure on machine labour (Rs/ha), X_3 = Seed cost (Rs/ha), X_4 = Manure and Fertilizers cost (Rs/ha), X_5 = Plant protection chemicals cost (Rs/ha), X_6 = Irrigation cost (Rs/ha), 'a' is the constant term and bi's are the regression coefficients to be estimated.

In this analysis, all input and output variables were expressed in monetary terms to facilitate the estimation of marginal value productivities and efficiency ratios.

Marginal Value of Productivity (MVP) denotes the Marginal Value Productivity, which reflects the additional monetary return generated from the use of one more unit of a particular input. The marginal value productivity (MVP) of input Xi (i=1,2…,6) for Cobb-Douglas functions are as follows:

$$MVP_i = bi\ \frac{\bar{Y}}{\bar{X}}$$

Where, $\overline{Y}$= Geometric mean of output, $\overline{X}$ = Geometric mean of input, bi = the regression coefficients associated with 'Xi' input.

Resource use efficiency represents the effectiveness with which inputs are employed to produce output in the production process. It is assessed by comparing the Marginal Value Product (MVP) of an input to its corresponding Marginal Factor Cost (MFC). In this study, the efficiency of each input was evaluated using the following formula:

$$r = \frac{MVP_i}{MFC_i}$$

Where, r represents the efficiency ratio, MVP denotes the Marginal Value Product, which reflects the additional monetary return generated from the use of one more unit of a particular input, MFC stands for the Marginal Factor Cost, which is considered as 1 because both the dependent and independent variables have been expressed in monetary terms. MFC represents the increase in input cost incurred from employing one additional unit of the input. An efficiency ratio equal to 1 implies optimal use of the input. Ratios greater than 1 indicate underutilization, while ratios less than 1 suggest overutilization of the resource.

RESULTS

Resource use efficiency

This section presents the estimated results related to input productivity and resource use efficiency for key inputs employed in potato cultivation across the selected districts. A summary of the findings is presented in Table 1. The R^2 values, ranging from 63.70 per cent to 71.05 per cent, suggest that the model demonstrates a good fit across all three districts. This indicates that the combined use of key agricultural inputs–human labour, machine labour, seed, manure and fertilizers, plant protection chemicals, and irrigation–explained a significant proportion of the variation in potato output.

Table 1. Regression coefficient and standard error of potato production in Selected Districts

Variables	Coefficients		
	Sonipat	Karnal	Kurukshetra
Constant	7.25	7.02	7.71
Human labour	-0.061*	-0.024NS	-0.057NS
	(0.04)	(0.12)	(0.07)
Machine labour	0.012NS	0.018NS	0.195***
	(0.07)	(0.11)	(0.04)
Seed	0.235*	0.622***	0.177NS
	(0.15)	(0.25)	(0.16)
Manure and Fertilizers	0.308***	0.209***	0.175**
	(0.05)	(0.07)	(0.07)
Plant Protection	-0.032NS	0.069NS	0.026NS
	(0.04)	(0.05)	(0.06)
Irrigation	0.051NS	-0.014NS	-0.045NS
	(0.05)	(0.07)	(0.07)
Return to scale	0.443	0.884	0.471
R^2(%)	71.05	63.70	67.18

Figures in parentheses indicates standard error
***Indicates significance at 1% level, ** 5% level, * 10% level and NS- Non-Significant

In Sonipat district, the coefficients for seed and manure & fertilizers were found to be positive and statistically significant at the 10 per cent and 1 per cent levels, respectively, indicating their strong influence on yield. In contrast, the coefficient for human labour was negative and significant at the 5% level, suggesting an inefficient or excessive use of manual labour. The remaining variables in the model did not exhibit statistical significance.

In Karnal district, seed input emerged as a critical factor, showing a highly significant positive coefficient of 0.622 at the 1% level. Additionally, manure and fertilizers had a significant positive effect (coefficient = 0.209) at the 1% level. However, other inputs such as human labour and machine labour were found to be statistically insignificant in explaining yield variation. In Kurukshetra district, the coefficient for machine labour was positive and highly significant at the 1% level, underlining the important role of mechanization in boosting productivity. Manure and fertilizers also exhibited a positive and significant effect at the 5% level. However, other inputs including seed, human labour, and irrigation, did not show statistically significant relationships with output. The sum of the regression coefficients in all three districts was less than one–ranging from 0.443 in Sonipat to 0.884 in Karnal–indicating decreasing returns to scale. This suggests that a 1 per cent simultaneous increase in all inputs would lead to less than a 1 per cent increase in output, reflecting either input overutilization or diminishing marginal returns under current production practices.

Marginal value productivities of inputs used in potato production

In this section, Marginal Value Productivities (MVPs) of key inputs used in potato cultivation were estimated to evaluate the efficiency of resource use across selected districts. The MVPs were derived from the regression coefficients of the Cobb-Douglas production function and reflect the additional monetary return from one additional unit of expenditure on a particular input. For the purpose of this analysis, the Marginal Factor Cost (MFC) of all inputs was assumed to be unity (MFC = 1), which is a standard practice when all variables are expressed in monetary terms (Sapkota & Bajracharya, 2018). This allows for direct comparison between MVP and MFC to assess the efficiency ratio (r = MVP / MFC). The MVPs, efficiency ratios, t-values, and resulting interpretation of input use are discussed below district-wise and presented in Table 2.

Table 2. Marginal value productivities of inputs used in potato production in Selected Districts

Input	Human Labour	Machine labour	Seed	Manure & Fertilizers	Plant Protection	Irrigation
Sonipat						
B	-0.06	0.01	0.23	0.31	-0.03	0.05
MVP	-1.01	1.50	2.15	2.71	-1.29	2.72
MFC	1	1	1	1	1	1
R	-1.01	1.50	2.15	2.71	-1.29	2.72
t- value	-1.45	0.16	1.55	5.81	-0.92	0.98
Level of resource use	Over Utilized	Under Utilized	Under Utilized	Under Utilized	Over Utilized	Under Utilized
Karnal						
B	-0.02	0.02	0.62	0.21	0.07	-0.01
MVP	-0.38	3.27	6.51	2.28	2.95	-0.62
MFC	1	1	1	1	1	1
R	-0.38	3.27	6.51	2.28	2.95	-0.62
t- value	-0.13	0.02	2.51	3.18	1.27	-0.21
Level of resource use	Over Utilized	Under Utilized	Under Utilized	Under Utilized	Under Utilized	Over Utilized
Kurukshetra						
B	-0.05	0.21	0.18	0.18	0.03	-0.05
MVP	-0.91	2.49	1.92	1.63	1.19	-3.23
MFC	1	1	1	1	1	1
R	-0.91	2.49	1.92	1.63	1.19	-3.23
t- value	-0.76	4.51	1.06	2.21	0.51	-0.65
Level of resource use	Over Utilized	Under Utilized	Under Utilized	Under Utilized	Under Utilized	Over Utilized

In Sonipat, machine labour (MVP = 1.50), seed (2.15), manure & fertilizers (2.71), and irrigation (2.72) were found to be underutilized, indicating that their increased use could yield higher returns. Particularly, irrigation and fertilizer application had the highest MVPs, suggesting strong potential for enhancing productivity through more optimal water and nutrient management. On the other hand, human labour (MVP = -1.01) and plant protection chemicals (MVP = -1.29) showed negative MVPs, indicating overutilization, potentially leading to reduced economic returns. The negative MVP of plant protection may reflect either excessive chemical use or ineffective pest/disease control measures. The t-values were generally low, indicating that statistical significance of individual coefficients should be interpreted with caution.

In Karnal, seed (MVP = 6.51) exhibited the highest value, followed by machine labour (3.27), plant protection (2.95), and manure & fertilizers (2.28), all of which were underutilized. This points to substantial scope for increasing potato yields by enhancing investment in quality seed, mechanization, plant health management, and fertilizer application. Human labour (MVP = -0.38) and irrigation (MVP = -0.62) were overutilized, possibly reflecting inefficient labour deployment and suboptimal water management practices. Notably, seed and fertilizer use were statistically significant and economically justified inputs. In Kurukshetra, the MVPs of machine labour (2.49), seed (1.92), fertilizers (1.63), and plant protection (1.19) indicated that these inputs were underutilized and could improve productivity if applied more effectively. However, irrigation (MVP = -3.23) and human labour (MVP = -0.91) were overutilized, particularly irrigation, which showed the most negative value across all districts, suggesting either overwatering or inefficient scheduling. The t-values reinforced the significance of machine labour and fertilizers, emphasizing mechanization and nutrient application as key factors for yield improvement.

DISCUSSION

The calculated coefficients of multiple determination (R^2) reveal that the chosen inputs–namely human labour, machine labour, seed, manure and fertilizers, plant protection chemicals, and irrigation–account for a significant share of the variability in potato output. Specifically, R^2 values of 71.05 per cent, 63.70 per cent, and 67.18 per cent were observed for Sonipat, Karnal, and Kurukshetra respectively. These findings indicate that the Cobb-Douglas production function is well-suited to the data across all three districts.

In Sonipat, seed and manure & fertilizers emerge as significant contributors to output, while machine labour, although not statistically significant, shows a positive relationship with productivity. The negative coefficient for human labour indicates overutilization, a finding also observed in the MVP results. Karnal shows a similar pattern, where seed plays a dominant role in yield improvement, followed by fertilizers and machine labour. Non-significant but negative coefficients for human labour and irrigation reflect inefficient resource deployment. In Kurukshetra, mechanization is found to be particularly crucial, while overuse of irrigation and human labour remains a concern. Similar studies on the economic aspects of potato cultivation, such as the one conducted in Agra district by Singh et al., (2019), have also emphasized the significance of efficient input management in enhancing profitability.

The Marginal Value Productivities (MVPs) corroborate these observations. Machine labour, seed, and fertilizers consistently show MVP/MFC ratios greater than one, pointing to underutilization and the potential for enhancing productivity through greater investment in these inputs. Conversely, human labour and irrigation reflect negative MVPs across all districts, underlining their inefficient or excessive application. In Kurukshetra, the notably negative MVP of irrigation (-3.23) highlights a critical issue in water resource management.

These findings underline the need for more balanced and optimized input use strategies. Overuse of labour and water not only inflates production costs but also reduces technical efficiency. Meanwhile, better seed quality, mechanization, and fertilizer use present opportunities to enhance output. These results align with earlier findings by Sujan et al., (2017); Kumar et al., (2021) & Kumar et al., (2023), who emphasized the importance of efficient input allocation in increasing agricultural productivity. Studies across different crop systems have also shown that economic performance and input efficiency vary significantly depending on farm practices and scale, underscoring the need for localized analysis (Chiphang et al., 2021).

Overall, the study underscores the value of adopting region-specific input strategies that focus on maximizing returns from underutilized resources while curbing the wasteful application of overused inputs. Improved access to credit, training on input management, and promotion of farm mechanization may further support the efficient use of resources in potato cultivation across Haryana.

CONCLUSION

The study evaluates the efficiency of resource use in potato cultivation using the Cobb-Douglas production function. The analysis shows that fertilizers and seed are significantly underutilized in all districts, indicating potential for increasing yield through improved nutrient management and seed quality. In Sonipat, a strong input-output relationship is observed, with a coefficient of determination (R^2) of 71.05 per cent. Human labour is overutilized, which contributes to inefficiency and higher production costs. Similar inefficiencies are evident in Karnal and Kurukshetra. In Karnal, seed shows the highest marginal return, suggesting it remains a critical area for investment. Irrigation exhibits negative returns, reflecting poor water use efficiency. In Kurukshetra, underutilization of machine labour highlights the importance of mechanization. These findings suggest the need for input optimization strategies to improve productivity and profitability in potato farming across Haryana.

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