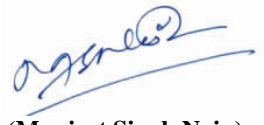
EDITORIAL

Even though reciprocal tariff levied by US government likely to put dent on Indian Agricultural Exports, still the tariffs are lower than our International competitors like Vietnam, China, Indonesia, Myanmar etc. As rural areas experience demographic shifts and younger generations increasingly disconnect from agriculture, more challenges emerge in attracting and retaining skilled agricultural workers to maintain the future viability of farming. Key farmer-centric programs like PM-KISAN, the Digital Agriculture Mission, and the National Mission on Edible Oils – Oilseeds (NMEO-Oilseeds) are making progress in empowering farmers and boosting agricultural productivity, with initiatives like drone services for women SHGs and credit guarantee schemes for post-harvest financing. Experts opine that India must transition from tariff-based protectionism to productivity-driven competitiveness. The key policy recommendations to phase tariff reduction on select outlier commodities, increased investment in agricultural research and development (R&D) to enhance yields and competitiveness, and strengthening agricultural value chains to boost exports. We need to develop contextual capacities and move from agriculture 1.0 (subsistence farming); agriculture 2.0 (intensive agriculture); agriculture 3.0 (precision agriculture); agriculture 4.0 (smart farming systems) to agriculture 5.0 (future farming systems-AI, IoT, BCT, Robotics etc.,). By adopting these strategies, India can navigate the evolving global trade environment while ensuring the resilience and growth of its agricultural sector.

The current issue (April-June, 2025) contains one research tool, five research notes, and seventeen full-length research papers. The diversity of full length papers focused on; Environmental management system adoption in Algerian agri-food companies, attainment of student engagement in learning, forecasting milk production, breaking the barriers of farm income through supplementary enterprises, Empowering Rural Women Entrepreneurs from Bihar, Relevancy of agri-clinic and agri-business center training curriculum for agripreneurs, Impact of soil health card on urea fertilizer usage and crop yield, Food, economic, and livelihood security of farmers under PMFBY, Value chain development of IARI carrot variety, Evaluating livelihood status improvement through attracting and retaining youth in agriculture (ARYA), Understanding entrepreneurial behaviour of Makhana growers, Effect of digital devices and parental regulations on adolescents' achievement motivation, Investigating researchers' skills and competency gaps of agriculture student, Growth Dynamics and Sustainability of Major Crops, Knowledge, Attitudes, and practices in sustainable nutrition in late adulthood ,and Perceptual analysis of diverse perspectives and desired proficiencies in 21st century skills . One research tool to measure farmers' training needs in drone-based technologies has been included. The research notes majorly focused on; Adoption practices of SRI in tribal region, Constraints in adopting improved cauliflower cultivation practices, Economic impact of extension interventions on composite carp culture, Adoption Impediments in SHC based fertilizer application by farmers and Understanding challenges of agripreneurs through case study. The cite score tracker of SCOPUS shows that with steady start of 0.4 (on 05 May, 2024 of 2023) we are at 1.1 on 05 March, 2025. (https://www.scopus.com/sourceid/21100846015)

I on behalf of the editorial board extend my sincere thanks to all those who directly or indirectly assisted the team editorial board. We acknowledge the contribution made by the reviewers by their name names included. We acknowledge Ms ACS publisher for maintaining timeline. All the expert members of the editorial board and willful contributors of authors are sincerely acknowledged. The support extended by 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)
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Research Article

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Environmental Management System Adoption: Challenges for Sustainable Development in Algerian Agri-Food Companies

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HIGHLIGHTS

- The study assessed ISO 14001 benefits, emphasising cost savings, waste reduction, pollution control, improved reputation, and enhanced global competitiveness.
- Challenges included high implementation costs, sub-contractor collaboration, and increased management expenses, all contributing to improved satisfaction rates.
- Positive correlations with cost reduction and SME adoption costs, and negative correlations with manager education and product quality was found.

ARTICLE INFO

Keywords: EMS, ISO 14001, Agri-food companies, Benefits, Challenges.

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ABSTRACT

The study, conducted between January and July 2024, identified the benefits and challenges faced by fifty-three ISO 14001-certified agri-food companies in Algeria. The current study's findings indicated that implementing an Environmental Management System (EMS) can result in significant cost savings by effectively managing natural resources, reducing waste, and controlling pollution. On the other hand, the significant challenges to adopt an EMS lie in the need for more collaboration from subcontractors, the fact that the savings achieved do not offset the expenses related to the rigorous implementation of management solutions, and the increase in management and operational costs. However, the implementation process requires significant effort and financial investment, which can be a limitation for some companies with significant positive correlations for parameters influencing the success of the adoption of the EMS system such as lowering costs ($p = 0.0000$), EMS adopting costs ($p = 0.0021$), and EMS maintenance costs ($p = 0.0112$) with EMS adoption. On the other hand, managerial education level ($p = 0.021$) and efforts to improve product quality ($p = 0.010$) exhibited significant negative correlations. Composite reliability values, ranging from 0.780 to 0.990, demonstrated strong internal consistency across the constructs measured.

INTRODUCTION

An Environmental Management System (EMS) is a structured and systematic framework designed to assist organisations in managing and mitigating their environmental impacts (Ferenhof et al., 2014). It encompasses a set of practices, policies, and procedures to minimise environmental footprints while promoting the sustainable utilisation of natural resources. (Voinea et al., 2020). EMSs facilitate the integration of environmental considerations into daily operations, enhancing overall environmental performance

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(Herghiligiu et al., 2019). An EMS involves several key steps : identifying environmental aspects, setting specific environmental objectives and targets, implementing detailed action plans, monitoring environmental performance, and continuously reviewing and improving the system (Carrillo-Labella et al., 2020). EMS standards have been established nationally and internationally as decentralised, voluntary environmental programmes. These standards have emerged in response to economic globalisation and increasing external pressures on companies regarding environmental issues (Testa et al., 2016). According to the ISO Survey of 2022, approximately 529,853 enterprises worldwide are certified to ISO 14001, making environmental management standards one of the most prevalent managerial practices globally, second only to ISO 9001 certification (Hayat & Lohano, 2024; Boulfoul et al., 2022). Adopting an EMS in the agro-industry encounters several substantial challenges. A primary challenge is the insufficiency of financial resources (Padilla-Bernal et al., 2018; Martin, 2020), which obstructs the necessary initial investments to adopt these systems. Numerous agri-food enterprises need more knowledge and competence regarding environmental management systems, impeding the incorporation of sustainable practices into their operations. Moreover, employees and management frequently resist change, as altering entrenched routines can be challenging. The intricacy of regulatory mandates may inundate firms, particularly smaller enterprises, which often need more resources for efficient compliance (Espinosa, et al., 2021). Furthermore, the considerable absence of assistance and direction from governmental and institutional entities deprives firms of the fundamental frameworks necessary for the proper execution of the EMS. The view of an EMS as a liability rather than a valuable asset may encourage agri-food enterprises to use it, thereby hindering their capacity for sustainable growth and environmental stewardship. Recent research indicates that the successful implementation of environmental management systems in the agri-food sector is significantly hindered by inadequate managerial support and commitment, which are critical for addressing these challenges effectively (Ikram, et al., 2021). It is essential to consider the extent to which implementing an environmental management system can help an organisation achieve its efficiency goals and the circumstances under which this is possible.

The primary aim of this study is to evaluate the advantages and obstacles associated with implementing the ISO 14001 standard. This research examines the key advantages of adopting an EMS, emphasising its contribution to reducing environmental risks, improving environmental protection within the agri-food industry, and promoting the advancement of environmental standards across the sector. The study seeks to identify challenges associated with implementing an environmental management system, including inadequate collaboration from subcontractors, cost savings that fail to compensate for the expenses incurred during the stringent implementation of management solutions, and a rise in management and operational costs.

METHODOLOGY

Data was collected using a structured questionnaire based on a comprehensive literature review of similar studies in other countries. To conduct this research, the questionnaire was designed with the help of consultants specialised in developing environmental management systems. The survey concerns fifty-three agri-food companies that represent all the ISO 14001-certified companies at the national level. The list of these companies was collected from the Algerian Institute of Standardization (IANOR) and the Ministry of Industry. Then, each company was called to confirm their willingness to participate in the study on adopting the EMS. Before drafting the research questionnaire, a preliminary survey was conducted among agri-food companies to assess the feasibility of the questionnaire and closely observe their production methods, addressing the main concerns related to the adoption of this system within these companies. This questionnaire facilitated the collection of opinions and information on adopting this system and managers' experiences in the food sector. During visits to the targeted food processing companies, the questionnaire was distributed to the company managers, followed by face-to-face interviews conducted over several sessions to ensure the accuracy of the responses. The face-to-face interview allowed participants to freely discuss their knowledge of adopting environmental management systems in Algerian agri-food companies. The survey included questions about the certification process, the reasons for pursuing certification, the benefits gained, and the challenges encountered during certification.

Furthermore, we asked the respondents to give us advice and suggest recommendations for companies wishing to obtain ISO 14001 certification. In this study, all statistical analyses were conducted using SPSS: the statistical package for social sciences, version 25. Initially, the software was used to statistically analyze the variables using descriptive statistics. Pearson's correlation analysis characterized the food companies that adopted the ISO 14001 standard. Subsequently, Cronbach's alpha, a standard coefficient, was employed alongside correlation analysis to evaluate relationships among key parameters influencing the successful implementation of the EMS within agri-food companies.

RESULTS

Characteristics of the companies

As shown Table 1, our sample comprises exclusively private sector enterprises, with no state-owned companies in the agri-food industry holding ISO 14001 certification. All individuals surveyed held positions as directors or managers. Our findings on company establishment reveal that over 50 per cent of enterprises fall within the 10 to 20-year age bracket. This trend is significantly influenced by the reforms that have been in place since 2000. In terms of legal status, a majority of companies are multinational (50%) or limited liability corporations (LLC) (33%). Conversely, a minority (17%) identify as joint stock companies (JSC), primarily due to the financial obligations imposed by shareholders, contrasting with the aforementioned legal statuses. Notably, a significant proportion of enterprises (77.8%) operate within a collective framework. Enterprises attribute their membership to its favourable impact on securing funding for their operations. Seventy per cent (70%) of the companies surveyed in our study meet these criteria. Additionally, a significant majority of companies fall into the category of large corporations, characterised by more than 500

Table 1. Main characteristics of the selected agri-food companies

Characteristics		Percentage
Contact person:Position held in the company	Managing Director	100
Agri-food companies' sector	Public sector	0
	Private sector	100
Year of company establishment	Less than 5 years	5,1
	Between 5 and 10 years	25,7
	Between 10 and 20 years	50,0
	More than 20 years	7,1
Legal status of the company	JSC	17
	LLC	33
	Multinational	50
Group membership	Yes	67
	No	23
Employees	1-250 employees	17
	250-500 employees	32
	500 employees	51
Revenue	Between 20 MDZD and 200 MDZD	17
	Between 200 MDZD and 2 billion DZD	17
	Between 2 billion DZD and 5 billion DZD	33
	≥5 billion DZD	33
Has the company already called on the services of quality institutions ?	IANOR	100
	ALGERAC	35,7
	ONML	92,9
	INAPI	85,7
Has the company already received support from cooperation programmes such as ?	SMEs I & SMEs II	7,1
	UNDP	7,1
	UNIDO	14.3
	DIVECO	14.3

Origin : Our team collected and analysed the data through a survey

employees and a turnover exceeding 5 billion Algerian dinars (DZD), constituting 51 per cent of the total. Conversely, medium-sized enterprises, employing between 250 and 500 individuals, represent the smallest segment at only 32 per cent. This distribution suggests that Algerian sized medium agri-food companies are effectively establishing themselves in the local market, influenced by financial constraints faced by domestic firms. Unlike other quality services, all enterprises consult IANOR institute, National office of legal metrology (ONML)and Algerian national institute of industrial property (INAPI) are closely followed, with consultation rates of 92.9 per cent and 85.7 per cent, respectively. In contrast, Algerian accreditation body (ALGERAC) has a lower consultation rate of 35.7 per cent compared to the top two organisations. Furthermore, a small fraction of companies have engaged in collaborative initiatives, which involve stringent criteria that are difficult to meet, reducing corporate participation likelihood. Ultimately, the State plays a crucial role in supporting businesses by offering financial assistance to enterprises implementing ISO 14001 certification, as evidenced by a substantial proportion (66.66%) in our sample. These subsidies are intended to promote the adoption of SME system certifications within agri-food companies, to mitigate environmental impacts, including water, soil, and air pollution. The company's moderate engagement with cooperation programs shows higher involvement in the United Nations Industrial Development Organization (UNIDO) and Diversification and Economic Cooperation (DIVECO) (14.3% each) compared to the Small and Medium Enterprises Support Program (SMEs) I & II and the United Nations Development Programme (UNDP) (7.1% each). This suggests a stronger alignment with industrial and economic diversification initiatives, while support from SMEs and UNDP appears to be underutilized. Enhancing participation in these programs could unlock additional growth opportunities.

Benefits of Implementing Environmental Management Systems

As shown in Table 2, data shows the key benefits of implementing the EMS. The most significant advantage, reported by over 98 per cent of respondents, is the reduction of environmental risks, encompassing air, soil, and water pollution. This outcome is largely attributed to companies' robust contributions to environmental protection and their strong compliance with industry environmental standards, achieving performance ratings exceeding 94 per cent. The most significant responses collectively highlight financial benefits : waste segregation enables cost-neutral or cost-positive disposal (88.67%), production costs are reduced through optimisedordering and minimised waste (90.56%), and an improved corporate reputation enhances overall business competitiveness (81.13%). Secondary benefits, such as

Table 2. Benefits of implementing an EMS in the agri-food companies

Responses	Disagree (%)	Somewhat agree (%)	Strongly agree (%)
Mitigating environmental risks, including air, soil, and water pollution.		1.89	98.11
Enhancing environmental protection within the broader society.		3.78	96.22
Advancing environmental standards throughout the industry.		5.66	94.33
The separation of waste results in disposal outcomes that are either cost-neutral or financially advantageous.		11.32	88.67
Minimizing production costs through streamlined procurement processes and strategies for reducing waste.		9.43	90.56
Enhancing the company's reputation to bolster its overall competitiveness		18.86	81.13
Reducing environmental claims		24.52	75.47
Enhancing the working environment for staff to increase morale	32.07	67.92	
Adherence to employers' pre-qualification criteria	37.73	62.26	

reduced environmental claims (75.47%), enhanced workplace morale (67.92%), and adherence to pre-qualification criteria (62.26%), indicate EMS's comprehensive advantages. Collectively, these findings emphasize that EMS adoption not only promotes environmental sustainability but also drives economic efficiency and operational resilience, solidifying its value for companies in the agri-food sector.

Obstacles to EMS implementation in agri-food companies

Table 3 provides a comprehensive overview of the responses addressing obstacles outlined in the questionnaire's implementation segment. The evaluation divides the challenges to EMS implementation into two categories : primary obstacles and secondary constraints. According to the data in Table 3, the respondents highlighted the key challenges to EMS implementation in the agri-food sector, which include: inadequate cooperation from subcontractors (90.56%), insufficient cost savings to justify the comprehensive adoption of management strategies (94.33%), escalating management and operational costs (98.11%), and a lack of customer support (90.56%). The less significant barriers in adopting an EMS include an increased documentary workload (81.3%), the time needed to enhance environmental performance (83.01%), challenges in coordinating environmental performance across multiple levels of subcontractors (79.24%), a shortage of trained staff and expertise (88.67%), lack of enforcement by regulatory authorities (69.81%), and insufficient technological support within the company (71.69%).

Reliability assessment of EMS consistency

As presented in Table 4, the reliability of all variables exceeded the recommended threshold for Cronbach's alpha (0.70), confirming strong internal consistency across the constructs. Cronbach's alpha values ranged from 0.780 to 0.990, indicating robust reliability for the variables measuring EMS adoption in agri-food companies. The highest Cronbach's alpha and CR values (0.990 and 0.980, respectively) corresponded to EMS implementation costs and lowering of costs, suggesting excellent internal consistency. These results indicated that the data used in this study were reliable and consistent, ensuring the robustness of the findings related to EMS adoption in the agri-food sector.

Relationship between factors and environmental management systems

The analysis of the relationship between specific parameters and the implementation of an EMS in food companies, as presented

Table 4. Results of the reliability tests

Responses	Cronbach's Alpha	Composite Reliability
Lowering of costs	0.980	0.980
EMS Implementation Costs	0.990	0.990
EMS Maintenance Costs	0.940	0.940
Manager level education	0.930	0.980
Manager age	0.880	0.880
Improve product quality	0.780	0.780

Table 3. Barriers encountered to EMS implementation in agri-food companies

Responses	Significant (%)	Highly significant (%)
Insufficient collaboration from subcontractors	9.44	90,56
The cost savings do not offset the expenses of rigorously implementing managementsolutions.	5.67	94.33
Rise in managerial and operational expenses	1.89	98.11
Lack of customer support	9,44	90,56
Increased documentary workload	18.7	81.30
Time allocated to enhancing environmental performance	16.99	83.01
Coordinating environmental performance among subcontractors at multiple levels is challenging.	20.76	79.24
Lack of trained staff and expertise	11.33	88.67
Governmental failure to enforce the law	30.18	69.81
Lack of technological support within the company.	28.31	71.69

Table 5. The relationship between specific parameters and the implementation of an ems in food companies

Parameters	Estimated path coefficient	Standard deviation (STDEV)	P values
Lowering of costs	0.578	4.012	0.0000
EMS adopting Costs	0.141	1.507	0.0021
EMS Maintenance Costs	0.164	1.599	-0.0112
Manager level education	-0.246	2.422	0.021
Improve product quality	-0.203	2.422	0.010

in Table 5, reveals significant findings. The correlation analysis shows a strong and positive relationship between cost reduction and EMS implementation, with a highly significant path coefficient of 0.578 and a p-value of 0.000, indicating a robust effect. In contrast, the costs associated with EMS adoption (path coefficient of 0.141, p = 0.0021) and EMS maintenance (path coefficient of 0.164, p = -0.0112) exhibit less significant but still noteworthy impacts on the EMS adoption process. Additionally, managerial education level (path coefficient of -0.246, p = 0.021) and efforts to improve product quality (path coefficient of -0.203, p = 0.010) show negative correlations, suggesting that higher education levels among managers and a focus on quality improvement may hinder the EMS adoption process. The results underscore the importance of cost-reduction strategies as a major driver for the successful implementation of EMS, while also highlighting potential challenges linked to adoption and maintenance costs, as well as managerial factors.

DISCUSSION

The adoption of an EMS, particularly ISO 14001, is a strategic tool for enhancing competitiveness, increasing market share, and driving sustainable growth (Bravi et al., 2020). The data in Table 2 highlights ISO 14001's effectiveness in improving organizational performance and fostering sustainable practices, particularly in companies without prior systems (Ahmed & Mathrani, 2023) ; Carrillo-Labella et al., 2020). Compliance with regulatory requirements reduces costs, while additional benefits, such as reduced waste production, enhance profitability and efficiency (Oliveira et al., 2016; Watson & Emery, 2004). Financial advantages include cost savings and improved competitiveness, appealing to environmentally conscious consumers willing to pay premiums for eco-friendly products (Ociepa-Kubicka et al., 2021). However, reduced environmental claims (75.47%) and improved working conditions (67.92%) are viewed as less impactful, consistent with Bielski et al., (2021) findings. While EMS implementation primarily drives financial and environmental benefits, further research is needed to explore the prioritization of profitability factors. Managers prioritise these aspects due to their significant impact on the benefits of adopting an EMS (Hillary, 2004).

The analysis of obstacles to EMS implementation in agri-food companies reveals key challenges, particularly in monitoring subcontractors' environmental performance, as highlighted by Kashakova et al., (2022). The study shows that increased management and operating costs are seen as significant barriers, with stakeholders questioning the return on investment for EMS adoption. These findings align with Castka & Balzarova (2018), who point out the high costs of obtaining and maintaining ISO 14001 certification, including external audits, staff training, and continuous improvement initiatives. Small and medium-sized enterprises are particularly affected by these financial and time burdens. Furthermore, the time-consuming nature of auditing, data collection, and staff training diverts resources away from addressing environmental concerns, reducing operational efficiency. The challenge of reshaping employees' mindsets and the extended training process also contributes to the complexity of EMS implementation, as noted by Carrillo-Labella et al., (2020).

The reliability assessment of SME consistency in implementing EMS in the agri-food industry reveals several key factors. Cronbach's alpha coefficients confirm the high reliability of variables related to EMS, including cost savings, implementation, and maintenance costs (Hair & Alamer, 2022). Composite reliability (CR) values, ranging from 0.780 to 0.990, further support the reliability of the data. A CR value above 0.70, as suggested by Kok Wei & Li (2013), confirms satisfactory reliability for all assessed variables. Well-educated managers and younger executives significantly contribute to the successful adoption of EMS due to their openness to innovative practices. Moreover, the primary motivation for adopting systems like ISO 14001 is to enhance environmental performance and gain access to international markets (Davydova & Sharno, 2023). However, high operational costs and insufficient financial support pose challenges, particularly for SMEs in Algeria (Figurek & Thrassou, 2023). The age of executives also impacts EMS adoption, with younger leaders being more receptive to new environmental practices (Turyakira et al., 2014). Finally, integrating EMS with product quality improvements provides dual benefits, enhancing both environmental performance and competitiveness (Granly & Welo, 2014; Journeault et al., 2021).

The correlation analysis of factors influencing the adoption of EMS in agri-food companies highlights the roles of lean and green management approaches. Lean management improves operational efficiency by eliminating inefficiencies, while green management focuses on reducing environmental impacts and promoting sustainability (Viles et al., 2021). ISO 14001 adoption shows improvement in both economic and environmental performance, reducing costs related to energy, raw materials, waste, and environmental impact (Santos et al., 2016; Zimon et al., 2022). For example, companies significantly reduce hazardous waste and water usage (Shah et al., 2019). The standard's systematic management of materials and energy leads to operational cost reductions, preventive maintenance, and regulatory compliance, which can prevent fines (Yu & Ramanathan, 2015). ISO 14001 also enhances organizational commitment through training and documentation of environmental procedures (Waxin et al., 2020). However, challenges remain in balancing the benefits and difficulties of its implementation (Boiral et al., 2018).

CONCLUSION

The study highlights the potential benefits of adopting an EM Swithin agri-food companies, particularly in terms of cost savings and environmental protection. However, the implementation of EMS presents challenges, particularly regarding the significant

investment required in terms of time, resources, and management effort. While cost reduction and effective waste management contribute to successful EMS adoption, the findings also point to the barriers posed by high implementation and maintenance costs, especially for small and medium-sized enterprises. Additionally, the study identifies managerial education levels and the focus on product quality as factors that could hinder the successful adoption of EMS. Therefore, overcoming these challenges will require strategic planning and investment to ensure that the benefits of EMS can be fully realized.

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Research Article

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Attainment of Student Engagement in Learning: An Empirical Investigation in Secondary Schools of Kerala

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HIGHLIGHTS

- Kerala's performance in terms of qualitative benchmarks such as student learning outcomes (SLOs) and equity is sub-optimum.
- The selected variables such as the parental education, social group and type of school had a significant impact on student engagement in learning in Kerala.
- Government and School administration should implement initiatives to improve student engagement in learning in an equitable manner in Kerala.

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ABSTRACT

High quality of school education can contribute significantly to socio-economic development of a region. In Kerala, quantitative parameters such as highest gross enrolment ratio (GER) and lowest dropout rate in school education are ideal. At the same time, Kerala's performance in terms of qualitative benchmarks such as student learning outcomes (SLOs) and equity are at sub-optimum. Conceptually quality is positively related to the achievement of SLOs, which in turn requires attainment of student engagement in learning (SEL). There is limited research on determinants of SEL in school education in Kerala. The present study aimed to investigate the SEL in Kerala. To achieve the goal, collected primary data from 584 students of private-aided schools (PASs) and state-government schools (SGSs) during the period from July 2024 to November 2024. To analyze the data, statistical tools such as Mean, Standard Deviation and F-test were used. The study found that selected variables such as mother's education, social-group and type of school of the students had significant impact on student engagement in learning in Kerala. Based on the findings, the paper recommends that the Government and School administration should implement initiatives to improve student engagement in learning in an effective and equitable manner in Kerala.

INTRODUCTION

Kerala is far ahead in terms of quantitative attainments such as high gross enrolment ratio, lowest dropout rate and lowest repetition rate in school education. For instance, the 'gross enrolment ratio' (GER) for 10th standard in Kerala was 90.6 per cent in 2020-21 and it rose significantly to 97.9 per cent in 2021-22 (National Achievement Survey, 2021; Ministry of Education, 2022; UDISE Plus, 2022). However, the attainment in qualitative parameters such as student learning outcomes (SLOs) are sub-optimum. It is obvious from the drop in ranking of Kerala from 'fourth' to 'seventeenth' position in the SLOs over the period from 2017-18 to 2021- 22. Kerala ranked 'second' with a score of 826 out of 1000 in Performance Grade Index (PGI) in 2017-18. Since then, its performance has deteriorated,

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dropping to 'fourth rank' in 2021-22 with 609.70 out of 1000 (Ministry of Education, 2018; National Achievement Survey, 2021; Ministry of Education, 2022; UDISE Plus, 2022). What are the causes behind this quality deterioration? Earlier literature argues that inadequate student engagement in learning (SEL) might be one of the causes of poor student learning outcomes (SLOs) (Vattanaamorn et al., 2022; Matsumoto et al., 2023). Based on this evidence, the role of student engagement in learning has gained utmost importance in the literature of educational quality, new educational policy and practice (Arun et al., 2022; Wong & Gregory, 2022). It might be due to its interconnection between student learning outcomes and student engagement in learning. The relevance of student engagement in learning during the various modes of learning is relevant. The learning takes various forms such as online, face-to-face and hybrid modes in India as well as in Kerala. Social networking and the quality of faculty also has implications on the development of student engagement in learning (Borah & Devarani, 2022; Devi & Sornapudi, 2022; Dhanwal et al., 2022; Sheoran et al., 2022; Mishra & Kumari, 2024).

Empirical findings indicate that there are various components that constitute student engagement in learning. There is less consensus on the applicability of each construct since they are unique and distinct. They argue that student engagement in learning would be the primary step towards the optimization of quality. Literature indicates that there is an intimate relationship between the quality of education in schools, learning outcomes and student engagement in learning (Vattanaamorn et al., 2022; Matsumoto et al., 2023; Arun et al., 2022; Wong & Gregory, 2022). Based on the importance of student engagement in learning, the present study presumes that inadequate student engagement in learning would be the prime cause behind the quality deterioration in Kerala. Based on the importance of student engagement in learning, the present investigation attempts to analyse student engagement in learning and the role of selected socio-economic and demographic variables which determined it.

METHODOLOGY

The study selected 10th standard students of private-aided and state-government schools for the survey. It was mainly because of the following reasons. (1) enrolment of students is the highest in state-government and private aided students in Kerala; (2) student learning outcomes (SLOs) of state government and private-aided students are sub-optimum compared to students in private-unaided and central-government schools and (3) 10th standard students are the highest group in higher secondary section (National Achievement Survey, 2021; Ministry of Education, 2022; UDISE Plus, 2022). After the fixation of population, the study divided the districts of state to the three categories based on the scores in performance Grade Index (PGI). From each category, one district from each stratum was randomly chosen for further processes. These districts were then divided into blocks, and two schools were selected from each block, representing both from state government and private-aided strata. Subsequently, the study approached sample schools and collected information of 10th standard students from the school register. From the information, the study divided them according to their social group, mother's education, father's education and gender (Havik & Westergård, 2020; Nambissan, 2020; Davis-Kean et al., 2021; Rani & Ravindranath, 2021; Dhar et al., 2022; Kamal, 2023; Nunez, 2023). Subsequently, sample students were categorized into five sections. They are:- (1) district; (2) ownership of school; (3) gender; (4) social group (5) father's education and (5) mother's education. Subsequently, the study selected students from each stratum randomly and ensured proportionate sample size from each stratum. The sample was selected through the 'Lahiri method' under probability proportionate size sampling techniques (Hounyo & Lahiri, 2023). As per the appointment of school administration and students, face-to-face interviews were conducted with sample students. For thefinalsurvey,196studentswereselected from the Ernakulum district, 212 from Kollam district, and 176 from Kozhikode district. Based on the sample size criteria, this study selected a sample of 584 students in the sample schools from Kerala. Total sample students were 584 in the study. In the analysis group, 251 students were from private-aided schools, whereas 221 students were from state-government schools. The students from forward caste were 272 and students from other backward castes (OBC) group were 191. Most of the mothers of sample students have an educational qualification of Secondary School Leaving Certificate (SSLC) or Plus-two categories, and their number was 266. Once the classification was completed, a 'structured questionnaire' was prepared.T he questionnaire had five sections and required items. Subsequently, a pilot study was conducted. The final primary survey was conducted through face-to-face mode between July 2024 and November 2024. Each interview with respondents took almost 40 to 45 minutes. Data collected through primary survey was tested for consistency and validity by using Cronbach's Alpha (Kennedy, 2022). Successively, the primary data was analysed by using tools such as Mean, Standard Deviation and F-test.

RESULTS

The results of the analysis are exhibited in Table 1. It depicts Mean and Standard Deviation of all 18 items to measure the level of student engagement in learningin schools in Kerala. The study selected some of the dimensions of student engagement in learning such as affective engagement in learning, behavioural engagement in learningand cognitive engagementin learning. The items on each dimension are exhibited in Table 1. The term 'student engagement in learning' may be interpreted as students' motivation to learn, state of flow and school connectedness. This construct may be elaborated that it is the students' interest, enjoyment and concentration in school work. Student involvement and academic engagement in learning are seemingly similar. These two branches of student engagement in learningare significant in attainments in education. The literature on student engagement in learningrevealed that there are some models that discussed the student engagement in learningin detail. They are:- (1) participation-identification model; (2) self-system model of motivational development; (3) flow theory; (4) school-work engagement; (5) participation-attachment-commitment-membership (PACM) model; (5) motivation and engagement wheel; (6) four-factor taxonomy; (7) agentic engagement and (8) social engagement (Ryan & Deci, 2017; Shernoff et al., 2017; King & McInerney, 2019; Wong & Liem, 2022). The present study treatsstudent engagement in learningas a multi-dimensional construct. It consists of affective in learning, behavioural in learning and cognitive in learning (Quin et al., 2017). The 'affective

Table 1. Student engagement in learning of secondary schools in Kerala

Component	Items	Mean	S.D
AffectiveEngagement in Learning	I enjoyed learning	5.18	1.243
	I have belongingness to my school	5.48	1.465
	I have a high interest in homework	5.87	1.308
	I am enthusiastic about learning at home	5.62	1.387
	I am happy in learning	5.89	1.153
	I have a good relationship with teachers in learning	5.39	1.117
BehavioralEngagement in Learning	I have a good relation with my mother in learning	5.81	1.287
	I have a good relation with my father in learning	5.47	1.258
	I have positive conduct in home	5.18	1.723
	I participate in extra-curricular activities in school	5.93	1.294
	I am ready to make effort	5.78	1.843
	I am able to concentrate on learning	5.66	1.756
CognitiveEngagement in Learning	I understand concepts clearly	5.73	1.238
	I am persistent in learning	5.59	1.489
	I follow self-regulated learning	5.26	1.297
	I know the value of learning	5.87	1.348
	I know the role of schools in future aspirations	5.93	1.634
	I am dedicated to strategies of learning	5.84	1.279

engagement' may include items such as enjoyment in learning, belongingness to school, interest in homework, enthusiasm on learning at home, happiness in learning, relationship with teachers, and relationship with mothers of student. The 'behavioral engagement in learning' may include items such as positive conduct in home, participation in extra-curricular activities in school, willingness to take effort, degree of concentration in learning, understanding concepts, and persistent in learning. The 'cognitive engagement in learning' may include items such as self-regulated learning, understanding the value of learning, understanding role of schools in future aspirations and dedication to strategies of learning.

Dimensions of student engagement in learningin school education in Kerala

Table 2 exhibits the results on the effect of socio-economic and demographic variables on the attainment of affective engagement in learning. It shows the F-test results of variables such as type of school, gender, social group, father's education and mother's education on the attainment of affective engagement in learningin students of 10th standard schools in state-government and aided schools in Kerala. The mean values of maximum variables are higher than the benchmark level and values of 18 variables are also at optimum. It indicates that all sample students have given their responses with respect to various choices. The results indicate that the range of standard deviation is ideal. The affective engagement in learningtreated as dependent variable and school, social group, father's education and mother's education are independent variables which could influence it. For variables such as school, social group, father's education and mother's education, the significance values are less than 0.05, indicating that there is a significant effect of these variables on affective engagement in learning. It hints that 'type of school' has a significant impact on the affective engagement in

Table 2. Impact of selected variables on the attainment of affective engagement in learning

Variable	Disparity	Sum of square	Degree of freedom	Mean square	F-value	P-value
School	Between the Groups	13.087	2	0.478		
	Within Groups	138.978	582	0.347	2.847	0.027
	Total	157.681	583			
Gender	Between Groups	0.184	1	0.184		
	Within Groups	151.809	582	0.319	.207	0.228
	Total	158.681	583			
Social Group	Between Groups	12.347	3	0.534		
	Within Groups	138.274	581	3.847	8.125	0.000
	Total	153.690	582			
Mother's Education	Between Groups	11.875	3	0.482		
	Within Groups	139.892	581	3.689	7.416	0.000
	Total	154.767	582			
Father's Education	Between Groups	13.875	3	0.472		
	Within Groups	138.921	581	0.489	3.416	0.024
	Total	158.767	582			

Table 3. Impact of selected variables on the attainment of behavioural engagement in learning

Variable	Disparity	Sum of square	Degree of freedom	Mean square	F-value	P-value
School	Between Groups	6.638	2	0.601		
	Within Groups	167.032	582	2.132	3.692	.014
	Total	175.567	583			
Gender	Between Groups	0.789	1	0.789		
	Within Groups	178.679	582	0.618	1.389	.262
	Total	175.686	583			
Social Group	Between Groups	10.685	3	3.568		
	Within Groups	165.995	581		.359	.000
	Total	175.867	582			
Mother's Education	Between Groups	5.801	3	2.967		
	Within Groups	167.756	581	0.594	5.253	.007
	Total	175.567	582			
Father's Education	Between Groups	6.729	3	0.708		
	Within Groups	169.489	581	2.815	3.879	.031
	Total	178.767	582			

Table 4. Impact of selected variables on the attainment of cognitive engagementin learning

Variable	Disparity	Sum of square	Degree of freedom	Mean square	F-value	P-value
Gender	Between Groups	0.084	2	0.98		
	Within Groups	178.742	582	0.827	0.165	0.689
	Total	191.836	583			
School	Between Groups	6.594	1	1.589		
	Within Groups	167.964	582	0.685	2.758	0.024
	Total	173.967	583			
Social Group	Between Groups	6.587	3	2.178		
	Within Groups	174.231	581		3.456	0.014
	Total	182.836	582			
Mother's Education	Between Groups	8.547	3	0.635		
	Within Groups	178.378	581	2.789	4.856	0.003
	Total	182.926	582			
Father's Education	Between Groups	7.859	3	0.987		
	Within Groups	169.895	581	1.827	0.165	0.089
	Total	174.857	582			

Source: Authors computed from primary data

learningin schools in Kerala. Table 3 depicts F-test results of selected variables on the attainment of behavioural engagement in learning in 10th standard in schools in Kerala. For variables such as school, social group, father's education and mother's education, the significance values are less than 0.05, indicating that there is a significant effect of these variables on affective engagement in learning. It signals that 'type of school' has a significant impact on the affective engagement in learningin schools in Kerala. It indicates that 'gender of the student' has an insignificant impact on the attainment of affective engagement in learningin schools in Kerala.

Table 4 depicts the impact of selected variables such as gender, social group, father's education and mother's education and school on the attainment of cognitive engagement in learning. Table 4 indicates that the selected variables have significant role in the attainment of cognitive engagement in learningin schools in Kerala. The P-value indicates that school, social group, father's education and mother's education are pivotal in determining the cognitive attainment in learning of students in schools in Kerala. On the contrary, 'gender of the student' has an insignificant effect on the cognitive engagement in learningon schools in Kerala. It is evident that 'gender' has an insignificant impact on the student engagement in in learning in Kerala. The major finding of the present study indicated that mothers' education of the student, father's education, schools attended and social group has significant impact on the student engagement in learning in Kerala.

DISCUSSION

Based on the analysis, it can be inferred that the variables which could affect student engagement in learning were social group, father's education, mothers' education, type of school attended, and gender of the students. Firstly, this study found that the 'social group of the student' is an important factor that could influence various dimensions of engagement in learning. Findings on the role of 'social group' in the present study appear to be similar to some of the

previous literature on quality and equity in school education. Previous literature argued that the 'social group of the student' would influence attainment in school education substantially (Havik & Westergård, 2020; Nambissan, 2020; Dhar et al., 2022; Kamal, 2023).

Secondly, the present study found that 'parental education of the student' seems to has a significant impact on student engagement on learning in Kerala. In other words, mothers have a crucial role in determining the attainment of student engagement in learningon school education in Kerala. It implies that parental support for their children is necessary in Kerala to improve student engagement in learning in Kerala. These findings appear to be supported by a positive role of parental education and involvement in the attainment of student engagement in learning (Davis-Kean et al., 2021; Rani & Ravindranath, 2021; Nunez, 2023).

Thirdly, the findings suggest that 'type of school' has a significant impact on the attainment of engagement in schools in Kerala. It may be due to theimplementation of a 'public rejuvenation campaign' and a 'mid-day meal scheme' in schools in Kerala. Similarly, the nature of school administration, teaching quality and human resource management also might have improved the performance of schools. The findings seem to be backed by some of the existing findings on the positive role of government schemes on education on student attainment in learning (Jayalakshmi & Jissa, 2017; Hoque, 2023; Paltasingh & Bhue, 2022; Thornberg et al., 2022).

In a nutshell, the present study attempted to examine the quality of school education in terms of student engagement in learning. There are various hindrances to the quality of school education in Kerala. Previous literature enquired various causes and dimensions of quality of school education in Kerala (Retnakumar & Arokiasamy, 2006; Sukumar & Kumar, 2015; Nambissan, 2020). However, they rarely enquired the interconnection between quality of school education and student engagement in learning. The present study argues that attainment of student engagement in learning (SEL) is the first and foremost step to improve the student learning outcomes (SLOs) in Kerala.

CONCLUSION

The present study finds that variables such as gender, parental education and social group have significant impact on the attainment of student engagement in learning in school education in Kerala. This finding indicates two factors. Firstly, student with educated parents can improve their engagement in learning. Secondly, students who has less-educated parents will be negatively affected in their education. Therefore, school administration and Government should arrange extra attention to the children whose parental education is insufficient. For instance, student-specific remedial courses and special coaching classes to parents will be fruitful. Secondly, 'schools' have a significant impact on the attainment of student engagement in learning in Kerala. 'Social group' also can significantly influence student engagement in learning in schools in Kerala.Based on the findings, the paper argues that the Government and School administration should implement initiatives to improve student engagement in learning in an efficient, effective and equitable manner in Kerala.

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Research Article

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Forecasting Milk Production in India: Strategic Insights for Policymakers and Farmers

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HIGHLIGHTS

- India's milk production is forecasted to increase from 239.1 million tons in 2024 to 321.4 million tons by 2033, indicating strong sector growth potential.
- Consistency between ARIMA and Holt's models ensures accurate and dependable forecasts.
- The application of FAO's Sustainable Food and Agriculture Framework can guide the dairy sector toward climate-resilient and environmentally sustainable practices.

ARTICLE INFO

Keywords: Indian dairy industry, ARIMA, Holt's exponential smoothing, Sustainable development.

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ABSTRACT

India's dairy sector plays a critical role in rural income, employment, and food security, contributing significantly to the nation's GDP. This study forecasts India's milk production for the period 2024–2033, using historical data from 1981–2023 obtained from the Department of Animal Husbandry and Dairying, Government of India. The study adopts ARIMA and Holt's Exponential Smoothing models for the forecasting of milk production in India, both the models reflected strong fits, with ARIMA excelling in capturing temporal structures and Holt's model focusing on linear trends. Performance metrics highlighted the high accuracy of both models, with R-squared values exceeding 0.99 and minimal error margins. The research provides actionable insights for farmers, policymakers, and other stakeholders. The results project milk production to increase steadily, reaching 315.6–321.4 million tons by 2033. The study highlights the potential of leveraging these forecasts for strategic planning, including synchronizing production with demand, improving market stability, and addressing infrastructural and environmental challenges.

INTRODUCTION

Milk production occupies a strategic position in India's economy as it is one of the important inputs in agriculture, rural income and nutrition. Indian dairy industry is very important on the global level as well as for the internal economy because India is the largest producer of milk in the world (Department of Animal Husbandry & Dairying, 2023). The sector supports more than 70 million rural, offers stable income and employment opportunities, especially small and marginal farmers (Shumway and Stoffer, 2017; TAAS, 2023) Besides, milk provides another protein-based food security for a predominantly vegetarian population (Lyngkhoi et al., 2022). The dairy industry of India makes up more than 4 per cent of the country's GDP, and the liquid milk segment is growing at annual rates ranging from 6-7 per cent (Suganthi, 2023). Apart from the economic roles the dairy industry also plays a significant

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social role by employing 70 per cent of the women (Fos, 2023). They are involved in animal husbandry, milking, and farm work, which has improved their financial and economic status as well as the welfare of the community (Kaur & Toor, 2024). The greatest impact on dairy farming was perceived as changes in the feeding behaviour of cattle (Singh et al., 2016; Phebe et al., 2024). Various government schemes such as Operation Flood, the Rashtriya Gokul Mission and the National Programme for Dairy Development have played major roles in changing the Indian dairy sector. Such programs increased milk production to 230.58 million tonnes in 2022-23 with a growth of 3.83 per cent per annum (Chand, 2023).

It is argued that appropriate forecasting is essential for the planning processes of the dairy industry. For farmers, it can be used to predict demand, balance resources, and match production cycles with demand. Likewise, the forecasts can be used by stakeholders such as government officials and business executives to counter market changes, enhance the supply chain, and develop effective strategies for all. Some well-known models to model agricultural data and to give precise forecasts are time series models such as ARIMA and Holt's Exponential Smoothing. These models will be used to predict India's milk production in the period 2024 to 2033 in this study. Thus, the opportunities that have been outlined in the analysis are aimed at providing decision-making support, solving the problems of the sector, and achieving sustainable development of the Indian dairy industry.

METHODOLOGY

This study forecasts India's milk production for the period 2024–2033 using ARIMA and Holt's Exponential Smoothing models, leveraging historical data. These models are particularly well-suited for univariate non-stationary data and effectively capture trends essential for agricultural forecasting. In contrast, the VAR (Vector Autoregression) model is ideal for the multivariate forecasting analysis, as pointed out by Hyndman & Athanasopoulos (2018). The data on the milk production (in million tonnes) utilised in the present study was collected from the Department of Animal Husbandry and Dairying from 1981 to 2023. The data was cleaned and prepared by removing the outliers and filling the missing values in the data in a statistical way (Chatfield, 2016). The data set was partitioned into the training set (1981–2018) for model training and into the validation set (2019–2023). The descriptive analysis was done using exploratory data analysis (EDA), and this included a time series and autocorrelation function (ACF) plot (Makridakis et al., 2018). ARIMA was derived from the Box and Jenkins approach, where the stationarity of data was tested using the Augmented Dickey-Fuller test while parameters in the model were selected from the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) diagrams (Box, 2013; Dickey & Fuller, 1979). As mentioned by Hyndman & Khandakar (2008), using AIC and BIC values to identify the best-fit ARIMA model, the selected model is (0,2,0) as shown in equation 1.

$$y''_t = y_t - 2y_{t-1} + y_{t-2} \quad ...(1)$$

Where, y_t is the value of milk production at time *t,* y_{t-1} is the value of milk production at the time *t-1,* y_{t-2} is the value of milk production at the time *t-2.*

Level and trend components were used to model linear trends in Holt's Exponential Smoothing with the optimal smoothing parameters ($\alpha = 0.9999$, $\beta = 0.8335$) for minimum errors as shown below in equations 2-4 (Holt, 2004; Box et al., 2015).

Level equation: $l_t = \alpha y_t + (1 - \alpha)(l_{t-1} + b_{t-1})$ ...(2)

Where, y_t is value at time *t,* l_{t-1} is a smoothed level at time *t-1,* b_{t-1} is a smoothed trend at time *t-1.* α is the smoothing parameter for the level ($0 \leq \alpha \leq 1$).

Trend equation: $b_t = \beta(l_t - l_{t-1}) + (1 - \beta)b_{t-1}$ ...(3)

Where, β is the smoothing parameter for the trend ($0 \leq \beta \leq 1$).

Forecast equation: $\widehat{y_{t+h}} = l_t + hb_t$ ...(4)

Where, $\widehat{y_{t+h}}$ is Forecast for *h* periods ahead, *h* is forecast horizon

Both models also passed the residual diagnostic checks that included the Shapiro-Wilk test for normality of the residuals and the Ljung Box test for independence of the residuals. The performance of the forecast was evaluated by the root mean square error (RMSE), the mean absolute error (MAE), and the mean absolute percentage error (MAPE) according to Makridakis et al., (2018). Due to these strong fits and reliable performance, both models were used to predict trends in milk production for the years 2024-2033. These forecasts serve as a valuable tool for understanding future demand, helping policymakers plan more effectively to address upcoming challenges. The data analysis was conducted using the Python programming language within the Google Collab platform.

RESULTS

The application of ARIMA (0,2,0) and Holt's Exponential Smoothing models provided key insights into the forecasting of milk production in India from 2024 to 2033. The results indicate that both models are effective in capturing the underlying patterns in milk production, although each offers unique advantages depending on the specific requirements of forecasting.

Model performance and error metrics

Table 1 highlights the performance metrics of the ARIMA (0,2,0) and Holt's Exponential Smoothing models. Both models demonstrate high accuracy in forecasting milk production, with minimal error values and strong explanatory power. The ARIMA model achieved an R-squared value of 0.9995, reflecting a high degree of explained variance, while the Root Mean Square Error (RMSE) was 1.1726, indicating a close alignment between predicted and actual values. The Mean Absolute Error (MAE) of 0.8709 and Mean Absolute Percentage Error (MAPE) of 1.04 per cent further confirm its precision. The model also showed strong suitability for capturing temporal structures with an Akaike Information Criterion (AIC) of 133.36 and a Bayesian Information Criterion (BIC) of 135.07.

Holt's Exponential Smoothing model also delivered robust results, with an R-squared value slightly higher at 0.9996. It demonstrated comparable accuracy with an RMSE of 1.1667, an

Table 1. Error Metrics Comparison of ARIMA and Holt's Exponential Smoothing Models

Measure	ARIMA (0,2,0)	Holt's Exponential Smoothing
R-squared	0.9995	0.9996
RMSE (Root Mean Square Error)	1.1726	1.1667
MAE (Mean Absolute Error)	0.8709	0.8766
MAPE (Mean Absolute Percentage Error)	1.04%	1.01%
AIC	133.36	184.9898
BIC	135.07	193.7958

MAE of 0.8766, and a MAPE of 1.01%. However, its AIC (184.99) and BIC (193.80) were higher than those of ARIMA, indicating a slightly less optimal fit. Despite this, the model effectively captured linear trends within the dataset, making it a reliable option for trend-focused forecasting. Both models exhibited minimal errors and strong fits, highlighting their reliability for forecasting milk production. The choice between ARIMA and Holt's models ultimately depends on specific needs, with ARIMA being better suited for capturing temporal structures and Holt's model excelling in trend-focused analysis.

Table 2 presents the residual diagnostic results for the ARIMA (0,2,0) and Holt's Exponential Smoothing models, confirming the adequacy of both models in terms of residual behaviour. For the ARIMA model, the Shapiro-Wilk test yielded a p-value of 0.1943, indicating that the residuals are normally distributed. Additionally, the Ljung-Box test produced a p-value of 0.1254, confirming the independence of residuals, and further validating the model's reliability. Similarly, the residual diagnostics for Holt's Exponential Smoothing model showed a Shapiro-Wilk test p-value of 0.1737 and a Ljung-Box test p-value of 0.1859. These results also confirm that the residuals are normally distributed and independent, demonstrating the adequacy of this model for forecasting.

Table 2. Residual Diagnostic Tests for ARIMA and Holt's Exponential Smoothing Models

	ARIMA	Holt's Exponential Smoothing
Shapiro-Wilk Test p-value	0.1943	0.1737
Ljung-Box Test p-value	0.1254	0.1859

The results from both tables signify the strengths of each model. While the ARIMA model offers a slightly better fit based on AIC and BIC values, Holt's method provides a comparable level of accuracy with a marginally higher R-squared. The choice between these models ultimately depends on the specific forecasting needs–whether a more nuanced approach to temporal patterns is required (favouring ARIMA) or a simpler trend-focused analysis (favouring Holt's method).

Forecasting values and trends

Table 3 displays the forecasted milk production values for each year from 2024 to 2033 using both models. The table provides a detailed comparison of the point forecasts along with separate columns for the lower and upper bounds of the 95 per cent confidence intervals, offering insights into the range of possible outcomes. Both ARIMA and Holt's models provided consistent forecasts, indicating a steady upward trend in milk production from 2024 to 2033. The forecasts generated by the ARIMA model start at approximately 239.1 million tons in 2024 and gradually rise to about 315.6 million tons by 2033. In comparison, Holt's Exponential Smoothing forecasts begin slightly higher, at 239.7 million tons in 2024, reaching approximately 321.4 million tons by 2033. The similarity in the forecasted values between the two models indicates high consistency and reliability in the projections.

Figure 1 illustrates the forecasted milk production in India from 2024 to 2033, comparing ARIMA and Holt's Exponential Smoothing models. The chart shows a steady upward trend, with confidence intervals highlighting the reliability of the projections. Both models align closely, reinforcing the consistency and accuracy of the forecasts.

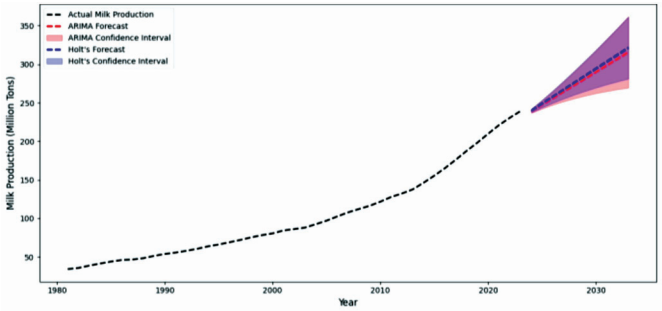

Figure 1. Milk Production Forecast in India (2024–2033): ARIMA vs. Holt's Models

Table 3. Forecasted Milk Production Values (2024-2033)

Year	ARIMA Forecast (Million Tons)	LW[1]	UB[2]	Holt's Forecast (Million Tons)	LW[1]	UB[2]
2024	239.1	236.7	241.5	239.7	237.3	242.1
2025	247.6	242.3	252.9	248.8	243.7	253.8
2026	256.1	247.3	264.9	257.8	249.7	266
2027	264.6	251.7	277.5	266.9	255.2	278.6
2028	273.1	255.6	290.6	276	260.4	291.7
2029	281.6	259.1	304.1	285.1	265.1	305.1
2030	290.1	262.3	317.9	294.2	269.5	318.8
2031	298.6	264.9	332.2	303.3	273.7	332.9
2032	307.1	267.4	346.8	312.3	277.5	347.2
2033	315.6	269.4	361.8	321.4	281	361.8

[1]Lower Bound Limit of the confidence interval; [2]Upper Bound Limit of the confidence interval

DISCUSSION

The projections of milk production in India for the period 2024 to 2033 offer valuable insights for strategic development and planning in the dairy sector. Based on historical data, forecasts utilizing ARIMA and Holt's Exponential Smoothing models indicate an upward trend in milk production. According to the ARIMA model, milk production is projected to increase from 239.1 million tons in 2024 to 315.6 million tons in 2033. Meanwhile, Holt's Exponential Smoothing method forecasts an increase from 239.7 million tons in 2024 to 321.4 million tons in 2033. While Holt's model estimates slightly higher production levels, the close alignment of the two models emphasizes their credibility and resilience. Both models highlight the sector's growth potential through data analysis. The projections signify the importance of synchronizing production with demand and leveraging cooperatives and value-added products to improve the resilience of rural communities. The study emphasizes that policymakers and societal stakeholders play a critical role in shaping the future of India's dairy sector. Addressing challenges such as inadequate infrastructure, demand volatility, and environmental issues is essential for sustained development.

The differences in projections between the models highlight the importance of selecting methodologies suited to specific conditions. ARIMA, with its small confidence intervals, is well-suited for risk-sensitive planning, whereas Holt's method is more appropriate for trend-focused planning. These findings are consistent with prior studies by Singh et al., (2014); Sharma et al., (2022) & Sowmya et al., (2023), which established the effectiveness of ARIMA in the Indian context. The study suggests strategies such as investments in supply chain management, technology, and sustainability to address the projected growth in milk production. These measures will prepare India to meet domestic demand and provide a competitive edge in the international dairy market, benefitting farmers, society, and policymakers alike.

CONCLUSION

India's dairy sector remains a vital segment of the rural economy and presents enormous potential for development and profitability. Market projections for milk production indicate that the sector may attain 315.6–321.4 million tons by 2033. These projections can help farmers, societies, and policymakers to better understand current challenges and opportunities, avoiding missed prospects. Guided by the principles of FAO's Sustainable Food and Agriculture Framework, farmers can improve production efficiency in response to market signals, adopt sustainable practices such as better resource management, and explore the value-added product market to enhance profitability. Communities should be empowered through knowledge sharing, affordable credit access, and robust cooperative networks to strengthen their economic resilience. Policymakers play a crucial role in creating a conducive environment by addressing infrastructure deficits, enhancing supply chains, and supporting climate-resilient practices, ensuring governance aligns with sustainable development goals. Societies can contribute by fostering rural livelihoods, supporting innovative practices in dairy operations, and promoting environmentally conscious strategies.

The adoption of advanced technologies such as artificial intelligence and data analytics aligns with FAO's principle of improving efficiency and minimizing environmental impacts. Cooperation among farmers, rural societies, and policymakers can drive sustainable development and elevate India's dairy sector's global competitiveness. By embedding FAO's framework into planning and decision-making, this work highlights the importance of coordinated efforts to unlock the sector's full potential for all stakeholders, ensuring its future viability and positive impacts.

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Research Article

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Breaking the Barriers of Farm Income through Supplementary Enterprises: A Step beyond Farming Systems

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HIGHLIGHTS

- Households involved with the technological interventions by the Krishi Vigyan Kendras could achieve higher income faster than the control households.
- Horticulture components contributed to the bulk of the household income and technology adoption hastened the income earning process from horticulture.
- Initiation into supplementary enterprises has showed the way forward for rapid strides in income generation opportunities for rural households.

ARTICLE INFO

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ABSTRACT

The study was conducted in ten districts of Karnataka in which Krishi Vigyan Kendras (KVKs) have introduced improved agricultural technologies and practices in selected villages during 2022. The interventions aimed at enabling the farmers to realize higher income from farm and non-farm activities. Propensity Score Matching was used to overcome the bias in sampling of treated and control category households. The probit analysis was applied to study the factors influencing household income. Agriculture + Horticulture + Livestock and Agriculture + Livestock were the most practiced farming systems by treatment and control group farmers, respectively. Increase in average net income was noticed in both the categories of the farmers over the benchmark. However, the highest net income was achieved by the treatment group farmers practicing Agriculture + Horticulture + Livestock + Supplementary enterprises. The importance of technological interventions was particularly evident when the same combination of enterprises practiced by the control category could only fetch lesser income.

INTRODUCTION

India continues to be a rural economy, with 66 per cent of its population living in rural areas (World Bank, 2019) and agriculture remains the mainstay of livelihood as it employs 42.3 per cent population and contributes 18.2 per cent in the country's GDP at current prices (GOI, 2024). Karnataka accounts for 5.83 per cent of the total geographical area of the country and contributes 8.4 per cent (2023-24) to the country's GDP. The share of agriculture, horticulture, animal husbandry and fisheries sectors in Karnataka GSDP is 13.04, 4.88, 3.78 & 0.57 per cent, respectively (GOK, 2024). Globally, farm income has been a policy concern, as the income gap between the agricultural and non-agricultural sectors as well as within the agriculture sector is widening (Vatta & Budhiraja, 2020). The average monthly income per agriculture household during 2018-19 was Rs. 10,218 (NSO, 2021) and a farmer earns only 20 per cent of the national per capita income (Birthal et al., 2017). Increased agricultural productivity aids in addressing low income and food insecurity but its success largely relies on technology uptake and utilization (GOI, 2018; Damba et al. 2020). Technology

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uptake and adoption by farmers is mainly influenced by access to technological information *viz*., frequency, usefulness and perception; trust in the information sources, experience with similar innovation and financial status (Ghadim & Pannell, 1999; IFAD, 2009; Abate et al., 2011; Toma, et al., 2018). Therefore, it is essential to create a suitable condition for the innovation usage to harness its fullest potential (Bayissa, 2015; Nain et al., 2024). Farmers are increasingly favouring commercial crops like oilseeds and fruits/vegetables over traditional food grains, reflecting a response to market demands and profit maximization (Majhi & Kumar, 2018; Gulati & Juneja, 2022). Agri-business and/or enterprises can change the lives of farmers (Bayissa, 2015) by generating higher revenue. Adoption of improved agricultural technologies, high value farming, and crop diversification scale-up the farm income (Tesfaye et al., 2016; Fan & Rue, 2020; Basantaray et al., 2023).

In order to enable farmers to harness the power of technologies in the entire array of agriculture, horticulture, livestock, fisheries and supplementary enterprises, Krishi Vigyan Kendras (KVKs) promoted technology-driven income enhancement strategies. Technology introduction through various mechanisms contributed to increased productivity as the first level of output, which encouraged farmers to reduce the area under less profitable food crops for growing new crops (diversification) and/or expanding the scale of operation (intensification). The additional revenue generated from diversification and intensification encouraged the farmers to venture into farm and non-farm enterprises. Transformation of farmers as agri-business entrepreneurs through farm and non-farm enterprises has been a new beginning (Chandre Gowda et al., 2023; 2024). It is important for the development agencies to understand the transformative processes happening in the rural areas. Hence an attempt was made to understand the composition and changes in income of farmers adopting diverse farming system combinations promoted and supported by KVKs to increase and sustain farm income.

METHODOLOGY

The study was carried out in ten districts of Karnataka namely Belagavi, Bidar, Chamarajanagara, Davanagere, Gadag, Hassan, Kalaburgi, Kodagu, Kolar and Udupi during the year 2022. The KVKs in these districts introduced improved agricultural technologies and practices with an aim to enable farmers achieve higher income from farm and non-farm activities. From among such villages, two villages were randomly considered to study the impact of the interventions on household income. Data from 400 farm families, at the rate of 20 households each in 20 treated villages, were collected. Eighty-four data sets had missing data and were deleted limiting the sample size to 316 households. For each of the treated village, one non-treated village was identified randomly to serve as the control. Similar to that of treated, data from 400 farm families in the 20 non-treated villages were elicited. Forty-five data sets were incomplete and were discarded and the sample size from non-treated villages was 355.

Propensity Score Matching (PSM) was employed to overcome the bias in sampling. Each treated household was matched with control household based on the observable covariates age, education, gender, family size, family structure, type of dwelling, family members involved in farming, landholding, irrigation and farm machineries. The PSM can be expressed as given in the equation 1.

$$e_i = \Pr(D_i = 1 \mid X_i) \quad \ldots(1)$$

Where, e_i is a propensity score and Pr is the probability of being treated will receive the value for D_i is equal to '1' and '0' otherwise (control) conditional on the vector of covariates X_i. Probit model (equation 2) was employed to estimate the propensity scores (Greene, 2002).

$$\Pr(D = 1 \mid X) = G(z) = {}^{X'}\_{-\infty}{}^{\beta}\beta\phi\,(z)dZ = \varphi(X'\,\beta) \quad \ldots(2)$$

Where, $G(z)$ is a function taking values between 0 and 1, ϕ is the standard normal probability density function, z is the vector of covariates and φ is the standard normal cumulative distribution function.

The computed probabilities were used for matching treated and control categories through four matching algorithms (Mossie, 2022) viz., Nearest Neighbour Matching, Kernel-Based Matching, Radius Matching and Stratification Matching. Average Treatment Effect on the Treated (ATT) was computed which represents the effect of the treatment, using equation 3. ATT is,

$$\alpha = E\,[Y_i(1)] - E\,[Y_j(0)] \quad \ldots(3)$$

where, α = treatment effect, E(Y) = Expected income, 1= treated, 0 = untreated (control)
i = i^{th} farmer

The difference between Y_i, a randomly allocated member of the treatment group and Y_j, a randomly assigned member of the control group, shows the treatment effect.

RESULTS

The average age of the farmers was around 47 years in the treated households and 49 years in the control. Majority of them had higher secondary and secondary education. Only 5 per cent in the control households and 18 per cent in the treatment were female and the rest were male. But, comparatively more female farmers represented the treated households. The average family size of treatment and control farmers was 4 and 5, respectively. Further, around 64 per cent of the treatment and 69 per cent of control farmers lived in nuclear type families and majority (treatment 224 & control 288) of them stayed in pucca houses. In both the categories, on an average three members of a family were involved in farming activities and the average landholding was around 2 hectares. Majority of the treatment (68.35%) and control (72.96%) farmers cultivated under irrigated condition.

The households covered in the study followed various farming systems detailed in Table 1. Among the treated households, the number of farmers who practiced only agriculture or only horticulture got slightly reduced during 2020-21 compared to the benchmark year but livestock farmers increased comparatively during the same period. Further, among the various farming systems, Agri. + Horti. was the most followed farming system and Agri. + Horti. showed declining trend for the treated groups. Integrated farming system (Agri. + Horti. + Livestock) was followed by more than 75 treatment farmers during both the years. During 2020-21,

Table 1. Farming systems practiced by the treatment and control group farmers in the study area

Farming system	Treatment (n=316)		Control (n=355)	
	2016-17	2020-21	2016-17	2020-21
I. Mono farming				
Only Agriculture (A)	61	54	76	61
Only Horticulture (H)	41	37	23	27
Only Livestock (L)	29	32	21	24
II. Farming system				
A+H	45	44	58	58
A +L	32	27	97	99
H+L	28	28	10	15
III. Integrated farming system (IFS)				
A+H+L	77	76	61	67
IV. Beyond IFS (Supplementary enterprises)				
Supplementary enterprises (S)	0	1	0	0
A+S	0	0	0	1
H+S	0	1	0	0
L+S	0	0	1	1
A+H+S	0	1	0	0
A+L+S	0	0	2	1
H+L+S	0	4	0	0
A+H+L+S	0	11	0	1

beyond integrated farming system 11 treatment group farmers adopted Agri. + Horti. + Livestock + Supplementary enterprise system. Similarly, in the control category, agriculture only was the most practiced mono farming system and the number of farmers who practiced only agriculture got slightly reduced during 2020-21 and farmers' practicing only horticulture or only livestock increased to some extent. Among the farming systems (control group), Agri. + Livestock was the most followed farming system and the number of farmers practicing H+L and IFS increased during 2020-21 compared to 2016-17. More than three-fifth of the control group farmers followed integrated farming system in both the years (Agri. + Horti. + Livestock). Further, up to eighteen households in the treated category progressed beyond integrated farming towards entrepreneurship as against four households in the control category by the year 2020-21.

The details on the annual income of treatment and control households are given in Table 2. There was increase in income during 2020-21 compared to baseline year in both the category households. The average net income of the treated households nearly doubled from Rs. 2,74,207/HH (2016-17) to Rs. 5,18,183/HH (2020-21). During 2016-17, the treated households earned Rs. 1,00,000 more than control households, which was further increased to Rs. 2,59,111/HH during 2020-21, twice higher than control households. In the mono farming systems of treated category, horticulture farming fetched higher income (Rs. 7,01,213/HH), more than twice the income from agriculture (Rs. 3,01,771/HH) during 2020-21. With the technological interventions in horticulture, the additional income was to the tune of Rs. 3,23,327/HH over baseline year, as compared to Rs. 83,536/HH in the control group for the same period.

Among the farming systems having two components, Horti. + Livestock system fetched higher income (Rs. 7,87,589/HH) with technological interventions contributing an additional income of Rs. 3,76,631/HH over baseline year. In the control category Agri + Horti

Table 2. Net income from various farming systems practiced by the treatment and control group farmers in the study area

Farming system	Treatment (n=316)				Control (n=355)			
	Net income (Rs. /HH)			t value	Net income (Rs. /HH)			t value
	2016-17	2020-21	Change in income		2016-17	2020-21	Change in income	
I. Mono farming								
Only Agriculture (A)	116161	301771	185610	1.734*	78184	109851	31667	1.789*
Only Horticulture (H)	377886	701213	323327	1.600	70622	154157	83536	1.645*
Only Livestock (L)	48347	120588	72241	2.690**	37489	82669	45180	3.629**
II. Farming system								
A+H	331267	303149	-28118	0.256	327966	496487	168521	1.942*
A +L	115527	351814	236287	2.648**	136086	209853	73767	3.915**
H+L	410958	787589	376631	2.464**	250270	382835	132565	0.954
III. Integrated farming								
A+H+L	422826	672933	250107	1.858*	257064	345652	88589	2.452**
IV. Beyond IFS								
Supplementary enterprises (S)	-	615000	615000	-	-	-	-	-
A+S	-	-	-	-	-	154515	154515	-
H+S	-	484991	484991	-	-	-	-	-
L+S	-	-	-	-	252100	273600	21500	-
A+H+S	-	235400	235400	-	-	-	-	-
A+L+S	-	-	-	-	223250	100122	-123128	-
H+L+S	-	457295	457295	-	-	-	-	-
A+H+L+S	-	1673171	1673171	-	-	122004	122004	-
Average net income (Rs/HH)	274207	518183	243976		167488	259072	91584	

Note: ** & * indicates significance at one and five per cent level of probability

system fetched higher income (Rs. 4,96,487/HH) during 2020-21 an increase of Rs. 168521/HH over 2016-17. The Agri + Horti + Livestock integrated farming provided an income of Rs. 6,72,933/HH during 2020-21, an increase of Rs. 2,50,107 over 2016-17, which was comparatively higher than added income of the control category (Rs. 88589/HH). The impact of technological interventions was very much visible for the treated households which switched over to supplementary enterprises for the first time. The households that chose Agri. + Horti. + Livestock + Supplementary enterprise system generated a net income of Rs. 16,73,171/HH, which was the highest over all other farming systems practiced by treated as well as control categories. The importance of technological interventions was particularly evident when the same combination of enterprises practiced by the control category could only fetch Rs. 1,22,004/HH.

The share of income from various sources for control and treated households during 2020-21 is given in Figure 1. The treated households earned 60 per cent of their income from horticulture compared to 49 per cent in the control group. Cultivation of agricultural crops contributed to 35 per cent of the household income for control group as against only 19 per cent for the treated households. Treated households were comparatively less dependent on agricultural crops cultivation for income. There was not much difference in the share of livestock income for both the categories of households and it provided 15 to 16 per cent income for both categories of households. Most important is that the treated households received five per cent of their income from supplementary enterprises while the share of the same for control households was very meager, as little as one per cent. The supplementary enterprises carried out by control group farmers were vermicomposting and kitchen garden whereas treatment group farmers were involved in various enterprises like mushroom production, beekeeping, nursery, seri-compost production, RTF bag production, custom hiring service, drip irrigation retail enterprise and also vermicomposting. Enterprise participation could be region and category specific (Tiwari et al., 2023), which needs the attention of the policy makers.

The results of the probit regression is given in Table 3. The factors such as education and number of family members involved in farming have positive influence. More than 65 per cent of treated farmers have education beyond secondary level. This implied that farmers' education level increased the participation in technology uptake and hence has a significant contribution (Jatav, 2024). Whereas, gender, family size, family structure, type of dwelling and no of farm machineries owned has negative influence on participation in technology uptake. Gender has negative influence indicating that if the farmer is a female, then it is less likely that the farmer will participate in technology uptake. Family size has negative influence on participation in technology uptake, depicting that smaller households had better participation in technology uptake. Type of dwelling had negative influence on participation in technology uptake, indicating that poorer households had increased participation in technology interventions. With increase in no. of farm machineries, the farmers' participation in technology uptake decreased. All pointed to the facts that the educated small holders were more involved in technological interventions and harnessed the benefits of technology uptake better than their counterparts.

Table 3. Probit model for determinants of participation in technology uptake

Particulars	Coef.	Std. Err.	z	P>z
Constant	3.429	0.565	6.070	0.000
Age	0.002	0.005	0.330	0.739
Education	0.138***	0.029	4.770	0.000
Gender (Female-1, Male-2)	-1.482***	0.196	-7.560	0.000
Family size	-0.074*	0.038	-1.960	0.050
Family structure (Joint-1, Nuclear-2)	-0.357***	0.127	-2.810	0.005
Family members involved in farming	0.093*	0.049	1.890	0.058
Type of dwelling	-0.346***	0.127	-2.720	0.006
Landholding	0.038	0.033	1.150	0.249
Irrigation	-0.195	0.121	-1.610	0.108
Farm machineries	-0.490***	0.051	-9.680	0.000

ATT estimates were obtained from the analysis which indicated the difference between the household income of the treated and control households (Table 4). The results of PSM showed that the treated households received higher income compared to Non-treated households. The average treatment effect on treated (ATT) was found to be significant in all the methods. It was observed that the treated households earned an additional income ranging from

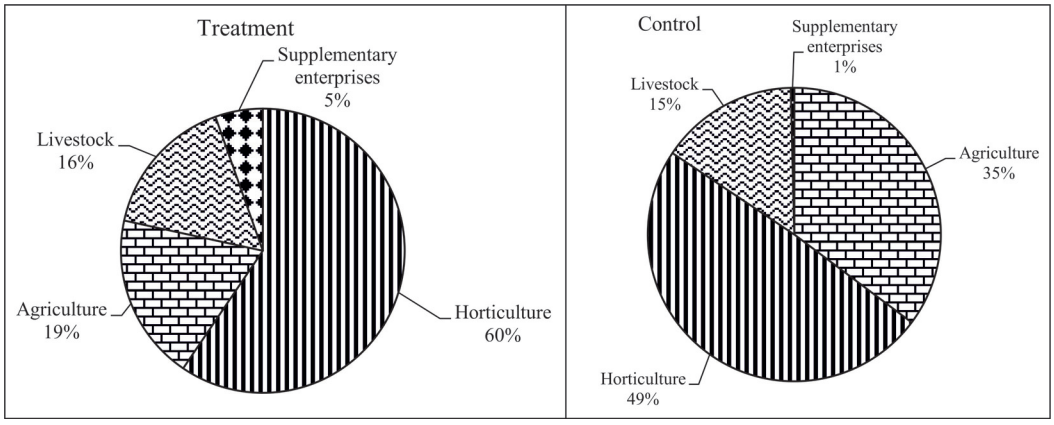

Figure 1. Share of income from various sources during 2020-21

Table 4. Impact estimates of technology uptake on household income of treated v/s control group

Matching methods	n. treat.	n. contr.	ATT	Std. Err.	t value
Nearest neighborhood (NN)	316	339	322747	63891.65	5.051
Kernel matching (KM)	316	339	305417	45803.20	6.668
Radius matching (RM)	316	339	300182	45871.13	6.544
Stratification	316	339	317326	42541.28	7.459

Rs. 3,00,182 to Rs. 3,22,747. The impact of KVK Interventions was clearly observed for the treatment group, which has higher income by Rs. 3,22,747 (NN). Thus, it can be clearly stated that KVK supported farm households earned more income than the control households.

DISCUSSION

Over the years (from 2016-17 to 2020-21), increase in the net income is noticed among both the treated and control group famers. The increase in income of the treated group farmers is attributed to increased productivity and reduction in cost of production. For example, in case of paddy cultivation, increase in productivity was 8.42 q/ha. Based on the average market price of Rs. 1231/q for the quantity produced by the farmers, the additional gross returns is Rs. 10369/ha. Even though there is an additional cost of Rs. 3625/ha, the net return is Rs. 6744/ha. Technology adoption further helps in lower production cost per unit (Rs. 56/q) which adds to the overall net income of the household. Likewise, in tomato cultivation, 203.29q/ha additional yield is achieved at an expense of additional Rs. 54047/ha, but at a reduction in unit cost of production (Rs. 53/q). This unit reduction in production cost per quintal results in additional overall net income of Rs.135544/ha. Thus the contribution of technology adoption is evident in multiple ways. Similar trend is noticed in other crops like maize, greengram, pigeonpea, groundnut, cotton, mango, chilli, onion, chrysanthemum, cardamom, black pepper, etc. Although there was not much change in the number of horticulture growers before and after, there is significant change in the share of income from horticulture among the treated households (60%), compared to control households, which is mainly attributed to technology uptake.

The t values for the households having livestock component like livestock alone, Agri + Livestock, Horti + Livestock, Agri + Horti + Livestock reveal significantly higher income over benchmark year compared to households without livestock component like Horticulture alone and Agri + Horti households. This is in line with the general trends about the growth rate and contribution of animal sector to agricultural GDP. The present study proved the importance of livestock in increased income during 2020-21 compared to benchmark year. The results are supported by Rajni & Walia (2016); Kumar et al., (2022); Seemakowsar & Gaddi (2024). The institutional and technological support provided by the KVKs was instrumental in encouraging the treated farm households to start supplementary enterprises, where none practiced any enterprises during 2016-17, but 18 households ventured into agri entrepreneurship during 2020-21. Within as well as between the treated and control category, the quantum of income contributed by supplementary enterprises is visibly superior to those households which did not take up entrepreneurship. This should augur well for the emerging importance for secondary agriculture, which demands farmers to progress from production oriented agriculture to beyond production, focusing on agri enterprises to boost income and sustainability of farming.

CONCLUSION

The emerging trend points towards farmers venturing into supplementary enterprises for realizing higher income. Need of the houris to sustain and scale up these supplementary enterprises through necessary policy and programmatic support. Horticulture constituted the major share of household income and share of agriculture is gradually decreasing. It puts the onus on the development departments and governments to strengthen the horticulture sector by addressing the bottleneck issues like storage facilities, supply and value chain strengthening, price monitoring and glut management. At the same time, it is crucial to address the collateral damages arising out of decreasing share of agriculture in household income. The issue of food security of the nation must always be handled carefully by ensuring the profitability for the food producers. The share of livestock in household income was almost same in both categories of farmers, which requires attention on the technological interventions that can enhance contribution from the livestock components in a farming system.

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Research Article

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Empowering Rural Women Entrepreneurs: Insights from Bihar

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HIGHLIGHTS

- Overall women empowerment in agriculture index was highest for mushroom entrepreneurs (67%) followed by stitching (65%) goat rearing (62%) and dairy farming entrepreneurs (56%).
- Innovativeness, education, decision-making ability, and planning skills are critical factors in achieving higher levels of women empowerment.
- Social barriers like dual responsibilities and traditional mindsets hinder women's participation in entrepreneurship development.

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ABSTRACT

Farm women play an important role in agrarian economy. This study aimed to explore the role of entrepreneurship in empowering rural women in an eastern Indian state of Bihar, where literacy rates are low and socio-economic opportunities are limited. The research was conducted in Bhagalpur district during 2019-20, covering a random sample of 80 women entrepreneurs, 20 each engaged in mushroom cultivation, goat rearing, dairy farming, and stitching enterprises. Using the social empowerment as well as women empowerment in agriculture index, as a composite measure, this study assessed empowerment across social dimensions- personal autonomy, family decision-making, and political autonomy as well as agro-economic dimensions- production, resources, time, leadership, and income. Among the enterprises studied, mushroom entrepreneurs demonstrated the highest levels of empowerment across most of the social and agro-economic dimensions, followed by stitching entrepreneurs. The goat rearing and dairy farming entrepreneurs were lagged with respect to social and agricultural empowerment, respectively. The stepwise regression revealed that innovativeness, decision making ability, level of education and planning ability explained 39 per cent variation in overall empowerment of women entrepreneurs. These aspects require to be considered for focused policy initiatives to promote entrepreneurship for the rural women.

INTRODUCTION

The status of women in a society is an indicator of the society's level of civilization. However, India faces a significant gender imbalance, with a disproportionately higher number of males compared to females. About 66 per cent of the female population in rural areas is underutilized in terms of their involvement in productive activities (Shettar, 2015). Despite considerable involvement and considering the role that women play in the society, gender inequalities exist in access to technologies, credit, information, inputs, and services including land and livestock and their contribution is rarely acknowledged (Singh et al., 2017; Jadoun, 2021). The main reason of this issue is social norms. In order to equalize the value of both genders and enable the country's overall development, women's empowerment must proceed at a rapid pace. Women's empowerment is characterized by the eradication of gender-based discrimination across societal institutions and

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structures, alongside the equitable inclusion of women in household and public policy decision-making processes (Priyanka et al., 2021). It is very important to empower women socially and economically as the livelihood of these farm women depend entirely on farming and related activities (Shamna et al., 2021). If women have easy, reliable and timely access to productive resources on par with men, women can increase yield by 20 to 30 per cent, raising the overall agricultural output in developing countries by 2.5 to 4 per cent. In addition to raising women's incomes, this production increase can cut the world's hunger rate by roughly 12–17% (FAO, 2011).

Women empowerment is defined as a re-distribution of social power and control of resources in favour of women during the International women conference held at Nairobi in 1985 (Goswami, 2013). Sen (2012) in his address to the 67th UN General emphasized that enhancing women's autonomy and decision-making capacity is crucial for achieving sustainable economic development and social progress. Making women economically independent and self-assured through entrepreneurial growth is one practical strategy to empower women, especially in Bihar. The notable gender wage disparity in Bihar, particularly in rural regions emphasizes that women are not only underpaid and undervalued for their labour, but also encounter obstacles when trying to obtain official job (Singh & Singh, 2023). This study focuses on rural women in Bihar due to its distinctive socio-economic challenges, providing a critical context for examining the role of entrepreneurship in rural women empowerment. Addressing these challenges through targeted interventions can contribute substantially to regional and national socio-economic development.

METHODOLOGY

The current study was carried out in the state of Bihar. Bhagalpur District was purposively selected from among Bihar's 38 districts due to the presence of the State Government's JEEViKA initiative, which promotes rural entrepreneurship, and the involvement of Bihar Agricultural University (BAU), Sabour, in capacity-building programs for rural entrepreneurs. Out of 16 blocks of Bhagalpur, two blocks i.e. Sabour and Goradih blocks were randomly selected. Four types of women enterprises were randomly selected and from each enterprise a random sample of 20 entrepreneurs were selected as respondents. Thus, a total of 80 women entrepreneurs were chosen as respondents in the present study.

Level of social empowerment of women entrepreneurs was measured with the help of index developed by Handy and Kassam (2004) with suitable modification according to the study area. A total of 18 items were listed under three sub-dimensions i.e. personal autonomy, family decision making and political autonomy. The response was measured on a three-point continuum; thus, the total score would range from 0 to 36. The empowerment of the women in their farming was also measured with help of Women Empowerment in Agriculture Index (WEAI) that is a composite index designed to measure progress the multi-dimensional aspects of women's empowerment. This index considers empowerment to be a factor of women's achievements in addition to gender parity with men. This index was developed by International Food Policy Research Institute (Alkire et al., 2013) that was based on five domains *viz.* production, time, resources, leadership, and income and 10 sub-domains under these five domains, each of which were given 20 per cent weightage. The response was measured on yes (1) or no (0) basis. The total score would range from 0 to 100 per cent.

Data were collected from the sampled respondents with the help of an interview schedule. Step-wise multiple regression analysis carried out considering women empowerment as dependent variable and socio-personal, socio-economic, communicational, psychological and entrepreneurial behavioural attributes of women entrepreneurs as independent variables. t-test was applied to understand the significant differences (if any) between the levels of social empowerment of different entrepreneurs and women empowerment in agriculture of different entrepreneurs analysed based on various five components as perceived by sampled respondents.

RESULTS

The personal autonomy of women entrepreneur was found as above average in three out of four selected categories of entrepreneurs (Table 1) with the mean score varied from 5.95 to 4.65. The mushroom entrepreneurs showed highest level of personal autonomy while entrepreneurs involved in goat rearing had it at the lowest level. Family decision making of women entrepreneur was found comparatively better. Like personal autonomy, decision making of mushroom entrepreneurs was highest (mean score of 6.65), while goat rearing entrepreneurs have least empowerment with respect to family decision making (5.30). Political autonomy of all the entrepreneurs was found at low level as the rural women were not empowered politically. Overall social empowerment level of the entrepreneurs varied from 35 to 47% that indicates below average level of position of the women entrepreneurs considering personal, decision-making and political autonomy together in rural areas.

Table 2 shows how women entrepreneurs in the Bhagalpur district of Bihar were empowered in relation to five different areas of agriculture. On an average, WEAI ranged from 56 to 67 per cent indicating all the four types of entrepreneurs showed relatively better empowerment in agriculture as compared to their social empowerment. Empowerment of all entrepreneurs with respect to production domain was found at an average to below average level. It was 10 out of 20 per cent in case of mushroom entrepreneurs, 8 per cent each in case of stitching and goat rearing entrepreneurs, and 7 per cent in dairy farming entrepreneurs. Empowerment related to resources varied from 8.67 to 12.01 per cent. Full empowerment was found in case of all categories of entrepreneurs regarding time domain. The empowerment of entrepreneurs in case of leadership was found at an average level (10 to 11.50%). However, the women entrepreneurs varied in their empowerment with respect to income as stitching entrepreneurs had higher empowerment level (15%) followed by mushroom entrepreneurs (14%), goat rearing entrepreneurs (13%) and dairy farming entrepreneurs (9%). Overall women empowerment index was about 67, 65, 62 and 56% in case of mushroom, stitching, goat farming and dairy farming, respectively.

Findings from the Table 3 suggests that innovativeness, decision making ability, level of education and planning ability had contributed significantly to the women empowerment. The R^2 value of 0.390 indicated that all these four variables contributed to 39 per cent of variation in women empowerment. Regression coefficient of all the four variables were found positively significant, which mean that

Table 1. Level of social empowerment of women entrepreneurs

S.No.	Particular	Mean perception score (SD)			
		Mushroom enterprise (n=20)	Stitching enterprise (n=20)	Goat rearing enterprise (n=20)	Dairy farming enterprise (n=20)
1.	Personal autonomy				
a.	Visiting parental home	1.45 (0.51)	1.40 (0.50)	1.35 (0.49)	1.45 (0.51)
b.	Visiting hospital	1.05 (0.22)	1.00 (0.00)	1.00 (0.00)	1.05 (0.22)
c.	Visiting Village Market	1.90 (0.31)	1.55 (0.51)	1.55 (0.51)	1.75 (0.44)
d.	Helping a relative with money	1.00 (0.32)	080 (0.52)	0.55 (0.51)	0.55 (0.60)
e.	Setting money aside for respondent use	0.55 (0.60)	0.40 (0.68)	0.20 (0.41)	0.30 (0.57)
	Overall score	5.95 (1.47)	5.15 (1.57)	4.65 (1.39)	5.10 (1.55)
	Personal autonomy index (%)	59.50	51.50	46.50	51.00
2.	Family decision making				
a.	Children's education in school	1.10 (0.55)	1.05 (0.60)	0.90 (0.55)	1.25 (0.55)
b.	Family planning	1.00 (0.46)	1.00 (0.56)	0.65 (0.59)	0.80 (0.70)
c.	Family day to day expenditure	0.95 (0.39)	1.00 (0.46)	0.85 (0.59)	0.85 (0.67)
d.	Going outside home	1.65 (0.49)	1.10 (0.55)	0.95 (0.51)	1.00 (0.56)
e.	Entertaining guests	1.95 (0.22)	1.95 (0.22)	1.95 (0.22)	1.95 (0.22)
	Overall score	6.65 (1.57)	6.10 (1.97)	5.30 (1.95)	5.85 (1.90)
	Family decision making index (%)	66.60	61.00	53.00	58.00
3.	Political autonomy				
a.	Voting according to own decision	0.80 (0.62)	0.50 (0.51)	0.30 (0.57)	0.30 (0.66)
b.	Awareness of any political issue	0.05 (0.22)	0.15 (0.37)	0.10 (0.31)	0.15 (0.49)
c.	Participation in any public protest	0.25 (0.44)	0.00 (0.00)	0.10 (0.31)	0.00 (0.00)
d.	Campaigning politically	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
e.	Standing for election	0.40 (0.50)	0.10 (0.31)	0.05 (0.22)	0.00 (0.00)
	Overall score	1.55 (1.36)	0.75 (0.72)	0.55 (1.23)	0.45 (1.10)
	Political autonomy index (%)	15.50	7.50	5.50	4.50
	Overall empowerment (%)	47.20	40.00	35.00	37.83

Note: Minimum and maximum possible scores of each statement are 0 to 2, respectively.

Table 2. Extent of women empowerment in agriculture

S.No.	Domains of empowerment	Mean Perception (%)			
		Mushroom enterprise (n=20)	Stitching enterprise (n=20)	Goat rearing enterprise (n=20)	Dairy farming enterprise (n=20)
1.	Production				
	Productive Decision	5.00	3.50	4.00	3.50
	Autonomy in Production	5.00	4.50	4.00	3.50
	Total	10.00	8.00	8.00	7.00
2.	Resources				
	Ownership of asset	0.33	0	0	0.33
	Access to credit	4.67	5.34	4.33	2.67
	Ability to purchase, sell or transfer assets	6.67	6.67	6.33	5.67
	Total	11.67	12.01	10.66	8.67
3.	Time				
	Productive and domestic task	10.00	10.00	10.00	10.00
	Available leisure time	9.50	10.00	10.00	10.00
	Total	19.50	20.00	20.00	20.00
4.	Leadership				
	Member of economic or social group	10.00	9.50	10.00	10.00
	Public speaking	1.50	0.50	0.50	1.00
	Total	11.50	10.00	10.50	11.00
5.	Income				
	Control over the income	14.00	15.00	13.00	9.00
	Total	14.00	15.00	13.00	9.00
	(WEAI)	66.67	65.01	62.16	55.67

Note: Minimum and maximum possible score in each domain is 20 and 0, respectively

Table 3. Step-wise multiple regression between women empowerment and attributes of rural entrepreneurs

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			
						F Change	df1	df2	Sig. F Change
1	.473	.224	.214	17.903	.224	22.485	1	78	.000
2	.550	.303	.285	17.079	.079	8.708	1	77	.004
3	.591	.349	.323	16.610	.046	5.415	1	76	.023
4	.625	.390	.358	16.183	.041	5.055	1	75	.027

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.713	11.909		.564	.575
	Innovativeness	36.446	7.686	.473	4.742	.000
2	(Constant)	.344	11.564		.030	.976
	Innovativeness	25.422	8.229	.330	3.089	.003
	Decision Making Ability	20.944	7.097	.315	2.951	.004
3	(Constant)	-4.386	11.428		-.384	.702
	Innovativeness	23.882	8.030	.310	2.974	.004
	Decision Making Ability	16.955	7.112	.255	2.384	.020
	Level of Education	4.126	1.773	.227	2.327	.023
4	(Constant)	-15.751	12.229		-1.288	.202
	Innovativeness	30.840	8.414	.400	3.665	.000
	Decision Making Ability	22.651	7.378	.341	3.070	.003
	Level of Education	4.593	1.740	.253	2.640	.010
	Planning ability	20.375	9.062	.258	2.248	.027

with higher innovativeness, decision making ability, level of education and planning ability, women empowerment will be higher.

Table 4 shows that level of empowerment of mushroom entrepreneurs' was significantly different from other entrepreneurs, involved in stitching, goat rearing and dairy farming which is evident from the significant t values at 6.3 and 1 per cent levels. Whereas, stitching, goat rearing and dairy farming entrepreneurs were not significantly different from each other.

Table 5 makes clear that there was no significant difference in the WEAI of the various entrepreneurs across the four enterprises. The types of entrepreneurships have not made any variations in WEAI that was measured on five domains of empowerment viz. production, resources, time, leadership, and income.

DISCUSSION

Present study revealed a relatively more social and agro-economic empowerment through mushroom enterprise followed by stitching, goat rearing and dairy farming enterprises. The outcome also shows how important women entrepreneurship is in achieving women's empowerment across various domains. The contribution of female entrepreneurs is reflected through economic growth, which is possible in two ways; firstly, they support economic growth through creating jobs, increasing per capita income, and capital accumulation, and secondly, they also contribute significantly to societal causes like innovation, better living standards, and balanced regional prosperity after launching micro enterprises (Malyadri, 2014). In fact, the women's empowerment is evidenced by their economic, social, and psychological advancement, facilitated through financial savings, enhanced decision-making authority, and increased self-confidence (Yasmeen & Gangaiah, 2014; Singh et al., 2014; Singh et al., 2016). Female farmers had greater authority than their male counterparts in the home, when it comes to time management and community leadership. Conversely, male farmers exhibited greater autonomy in financial decision-making, access to productive resources, and control over production decisions compared to their female counterparts; 28 per cent of women were categorized as

Table 4. t-statistics showing difference between levels of social empowerment of different entrepreneurs

Comparison between entrepreneurs	t	df	Sig. (2-tailed)
Mushroom entrepreneurs and Stitching entrepreneurs	1.973	19	.063
Mushroom entrepreneurs and Goat rearing entrepreneurs	2.909	19	.009
Mushroom entrepreneurs and Dairy farming entrepreneurs	2.956	19	.008
Stitching entrepreneurs and Goat rearing entrepreneurs	1.283	19	.215
Stitching entrepreneurs and Dairy farming entrepreneurs	0.544	19	.593
Goat rearing entrepreneurs and Dairy farming entrepreneurs	0.760	19	.457

Table 5. t-statistics showing difference between WEAI of different entrepreneurs

Comparison between entrepreneurs	t	df	Sig. (2-tailed)
Mushroom entrepreneurs and Stitching entrepreneurs	0.265	19	.794
Mushroom entrepreneurs and Goat rearing entrepreneurs	0.734	19	.472
Mushroom entrepreneurs and Dairy farming entrepreneurs	1.682	19	.109
Stitching entrepreneurs and Goat rearing entrepreneurs	0.488	19	.631
Stitching entrepreneurs and Dairy farming entrepreneurs	1.517	19	.146
Goat rearing entrepreneurs and Dairy farming entrepreneurs	0.970	19	.344

disempowered, with an overall women's empowerment index score of 0.83 (Ana Raj et al., 2022). According to Ojha & Mishra (2013), empowerment resulted in increased involvement, decision-making authority, and command over transformative action. In present study the attributes like innovativeness, decision making ability, level of education and planning ability have influenced the level of empowerment of women entrepreneurs. The annual income, use of information sources, social participation, extension activity participation, training, and innovativeness were responsible for 53.9 per cent of the variation in the women's empowerment level of aquaculture entrepreneurs in Odisha (Sahoo et al., 2023).

CONCLUSION

The study emphasizes the transformative potential of entrepreneurship in empowering rural women and addressing gender disparities. Women entrepreneurs demonstrated varied levels of empowerment, with mushroom entrepreneurs achieving the highest overall empowerment (67%). However, political autonomy remains alarmingly low across all enterprises, reflecting systemic socio-cultural barriers. The results highlight the necessity of focused initiatives to close these disparities, including education, skill development, and improved infrastructure. Entrepreneurship not only boosts women's economic independence and self-confidence, but also enhances their decision-making capabilities, contributing to broader societal progress. Practical implications include the necessity for government initiatives to prioritize rural women's access to resources, training, and credit facilities while addressing entrenched social norms. In line with national and international objectives for social justice and sustainable development, empowering women via entrepreneurship can boost gender equity, accelerate economic growth, and lower poverty.

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Research Article

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Relevancy of Agri-Clinic and Agri-Business Center Training Curriculum for Agripreneurs: A Study in Uttar Pradesh

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HIGHLIGHTS

- Communication Skills had the highest relevancy (72.67%) in the Entrepreneurial Development phase, while Problem Solving scored the lowest (54.34%).
- Enterprise Planning was most relevant (78%) in the Enterprise Planning and Resourcing phase, whereas Mobilization of Resources scored the lowest (58.34%).
- Related Case Studies had the highest relevancy (79%) in Entrepreneurial Management, while Cash/Fund Flow was least relevant (55%).
- Exposure Visits (81%) were the most relevant in Entrepreneurial Planning, while Market Survey: Report and Analysis was the least (53.67%).
- Agripreneurs found training methods and content highly relevant, emphasizing critical topics for effective entrepreneurial development programs.

ARTICLE INFO

Keywords: Agri-Clinic and Agri-Business center, Agripreneurs, Training relevancy, Enterprise and curriculum.

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ABSTRACT

The Agri-Clinic and Agri-Business Center (AC&ABC) programis designed to train rural youth in agricultural skills, enabling them to start their own ventures and support farmers. This study was carried out from March to September 2021, analyzed the relevancy of training courses provided under the scheme by nodal training institutes in enhancing entrepreneurial success. A total of 100 respondents from a nodal training institute in Varanasi participated, and Data was gathered using a pre-tested interview schedule following an Ex-Post-Facto research design. Findings revealed that, in the Entrepreneurial Development phase, the relevancy index ranged from 54.34 per cent for “Problem Solving” to 72.67 per cent for “Communication Skills.” In the Enterprise Planning and Resourcing phase, scores varied between 58.34 per cent for “Mobilization of Resources” and 78 per cent for “Enterprise Planning.” For the Entrepreneurial Management phase, the lowest score was 55 per cent for “Cash/Fund Flow,” and the highest was 79 per cent for “Related Case Studies.” In the Entrepreneurial Planning phase, the relevancy index ranged from 53.67 per cent for “Market Survey: Report and Analysis” to 81 per cent for “Exposure Visits”. Key challenges were social stigma (60%), market fluctuations (59%), pricing (40%), and climate (33%). The study recommends refining AC&ABC training with enriched content, digital literacy, strategy, and experiential learning.

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INTRODUCTION

In today's economic climate, possessing knowledge of an academic discipline alone is no longer adequate for new graduates. Employers are increasingly looking for candidates with skills that improve their employability, including the ability to retrieve and manage information, communicate and present effectively, plan and solve problems, and engage in social development and interaction. Entrepreneurial education and training help individuals recognize business opportunities, increase self-confidence, and acquire the knowledge and skills needed to take advantage of those opportunities. Agriculture has undergone significant changes over the past few decades (Singh et al., 2022). Traditionally viewed as peasant farming combining livestock and crop production, agriculture was once synonymous with crop cultivation. Most people lived on or near farms and were largely self-sufficient. Today, agriculture is evolving into a technological and market-oriented industry, encompassing agricultural produce, advanced agri-science, and agribusiness (Gandhi, 2014; Gupta et al., 2023; Singh et al., 2023; Singh et al., 2024). Notably, Shukla et al., (2024) and Roy & Ghosh (2022) observe that farmers increasingly prioritize market-related information, realizing that market-oriented agriculture is more profitable than conventional methods. Entrepreneurship now plays a pivotal role in uplifting national agricultural development programs, aiming for self-sufficiency in food production (Darmadji, 2016). The Agri-Clinic and Agricultural Business Center (ACABC) scheme supports entrepreneurship development in agriculture and allied sciences. Since its inception in 2002, the program has facilitated public extension services, spurred agricultural development, and trained unemployed youth, including women, for self-employment (Chahal & Ponnusamy, 2014; Maheswari et al., 2022; Bairwa et al., 2015). Managed by MANAGE, the "Agri-Clinics and Agribusiness Centres (ACABC)" initiative, launched by the Ministry of Agriculture and Farmers' Welfare (MoA&FW), selects candidates based on eligibility, qualifications, motivation, and commitment (Afroz et al., 2021; Afroz, 2022). The program's primary objective is to complement public extension efforts by promoting Agriventures and Agri-Clinics led by qualified agricultural professionals (Kumari et al., 2024). ACABC also provides self-employment opportunities for agripreneurs while offering value-added extension consulting services to farmers (Karjagi et al., 2009). Agribusiness activities span pre- and post-harvest processing, storage, shipping, packaging, labeling, innovative agricultural techniques, farm technology, and farm inputs (Bairwa & Kushwaha, 2015). The "agribusiness industry" includes all companies engaged in agriculture, such as those supplying seeds, processing food, or manufacturing machinery (Bairwa et al., 2014). Kumar et al., (2014) add that it also involves entities enhancing the marketability, edibleness, or storability of agricultural products and residues, whether food-related or not. The ACABC scheme offers a subsidy of 44 per cent for women, SC/ST candidates, and individuals from North-Eastern and Hill States, while other groups receive a 36 per cent subsidy (Nidhi et al., 2017). The program includes 45 days of residential training designed to develop entrepreneurship skills and increase participants' chances of becoming successful entrepreneurs (Chandrashekar, 2012; Deshmukh et al., 2023). However, there are limited studies evaluating the training programs under the ACABC scheme. Thus, assessing the adequacy and relevance of these training courses, provided by the nodal training institutes, became a key focus to analyze their effectiveness in enhancing enterprise success rates.

RESEARCH METHODOLOGY

The study conducted in 2021 focused on Sree Maa Guru Gramodhyog Sansthan, an NGO based in Varanasi, Uttar Pradesh. This organization trained more than5,500 graduates, of whom around 3,800 went on to establish agriventures. Out of 3,800 agripreneurs, a total of 100 Agri Clinic founders were chosen randomly, with the simple criterion that they were operating their Agri Clinics successfully for the last three years and ex- post-facto research design was used for the study. All the respondents who were selected had undergone training at the designated training institute, Sree Maa Guru Gramodhyog Sansthan, and subsequently started their own businesses after completing the training (https://smggs.org/). To assess the trainees' perception of the relevance of the training program content, the course materials from various training programs were systematically gathered and analyzed. These materials were collected as secondary data from different training institutes across Uttar Pradesh. The objective was to assess how relevant the trainees found the topics covered in these training programmes. To achieve this, data were collected from respondents using a structured questionnaire that measured their responses on a three-point continuum. The three response categories included "More Relevant," "Relevant," and "Not Relevant," with numerical values assigned to each category: 3 for More Relevant, 2 for Relevant, and 1 for Not Relevant. This scoring system allowed for a quantitative analysis of the trainees' perceptions. Each respondent evaluated the relevancy of multiple training content items, and their scores across all items were summed to compute their total score. The study focused on all33 curriculum topics of ACABC, covering a wide range of subjects relevant to the training programmes. Since each topic could receive a maximum score of 3, the highest possible total score for a respondent was 99 (It's because of the maximum score of each topic is 3 and total number of topics are 33). By aggregating individual scores, the study aimed to provide a clear understanding of how trainees perceived the relevancy of the training programme content. The data analysis helped identify which topics were considered most relevant, moderately relevant, or less relevant by the trainees, offering valuable insights for improving future training programmes. The relevancy index was measured using the formula as given below:

$$\text{Relevancy Index} = \frac{\text{Total score obtained}}{\text{Maximum possible score}} \times 100$$

RESULTS

Among the established ventures, 46 per cent are engaged in animal husbandry, including dairy, fisheries, poultry, and goat farming, while 20 per cent focus on crop production and nurseries. It also identified key challenges faced by these entrepreneurs, such as social stigma related to self-employment (60.00%), market fluctuations (59.00%), pricing difficulties (40.00%), and unpredictable climatic conditions (33.00%). The effectiveness of

any training program depends largely on the relevance of its curriculum to the trainees. This study aimed to assess the impact of training provided at the Agri-clinics and Agri-business Centres (ACABC) in Varanasi by analyzing feedback from participating agripreneurs. The training curriculum was structured into four distinct phases, namely the entrepreneurial development phase, enterprise planning & resourcing phase, entrepreneurial management phase, and entrepreneurial planning phase—each addressing specific aspects of agribusiness and entrepreneurship. The Relevancy Index derived from this study provided valuable insights into the topics that agripreneurs found most practical and beneficial.

Entrepreneurial development phase

The Relevancy Index for various topics in the Entrepreneurial Development phase highlights the perceived usefulness of each topic among the trainees (Table 1). Communication Skills emerged as the most relevant, with the highest Relevancy Index of 72.67 per cent, emphasizing its importance in effectively delivering messages, reducing communication gaps, and leading ventures. Farmer Relationship Management followed closely with a Relevancy Index of 70.34 per cent, underscoring its role in fostering strong customer relationships and enhancing enterprise performance. Networking with Farmers and Farmer Groups (62.67%) and Entrepreneurial Characteristics of an Agripreneur (62%) were also considered moderately relevant, indicating their significance in building professional networks and understanding entrepreneurial traits. Topics like Presentation Skills (58.67%) and Personality Enhancement (57.67%) scored lower but still demonstrated a moderate level of relevance in improving the agripreneurs' confidence and personal development. Problem Solving, with the lowest Relevancy Index of 54.34 per cent, was perceived as less practical, possibly due to its broad scope and limited immediate application in real-life scenarios.

Enterprise planning and Resourcing Phase

The Relevancy Index for topics in the Enterprise Planning and Resourcing phase indicates the perceived importance of different components in this stage of training. Enterprise Planning was rated as the most relevant topic, achieving the highest Relevancy Index of 78 per cent. This highlights its critical role in guiding decision-making and providing clarity on various aspects of business operations. Experience Sharing by Successful Agripreneurs followed

Table 1. Relevancy Index obtained for various phases

Trait	Total score obtained	Relevancy index (%)
Phase 1: Entrepreneurial Development		
Personality Enhancement	173	57.67
Communication Skills	218	72.67
Presentation Skills	176	58.67
Farmer Relationship management	211	70.34
Networking: Farmers and Farmer groups	188	62.67
Problem solving	163	54.34
Entrepreneurial Characteristics of an Agripreneur	186	62
Phase 2: Enterprise Planning & Resourcing		
Enterprise Planning	234	78
Small Enterprise Management: SWOT Analysis	213	71
How to Run a Small enterprise	200	66.67
Mobilization of resources	175	58.34
Experience Sharing By successful Agripreneurs	226	75.34
Agri Business: opportunities, technologies, Schemes & Value chain	204	68
Phase 3: Entrepreneurial Management		
General Management: Principles & Practices	205	68.34
Human Resource Development	192	64
Project Management	213	71
Agri – business management	202	67.34
Book Keeping	168	56
Cash / Fund Flow	165	55
Basic Computer Skills	177	59
Phase 4: Entrepreneurial planning (Agri specific)		
Type of Organization	202	67.34
Source of information: Enterprise specific	191	63.34
Environment scanning-Market Survey	172	57.34
Resource Analysis and counseling	169	56.34
Exposure visits	243	81
Project Identification By trainees & preparation,	212	70.67
Project Identification presentation and counseling	205	68.34
Market survey: Tools and techniques	166	55.34
Market survey: report and analysis	161	53.67

with a Relevancy Index of 75.34 per cent, underscoring the value of learning from real-life success stories and practical insights shared by experienced professionals. Small Enterprise Management: SWOT Analysis scored 71 per cent, reflecting its importance as a framework for analyzing strengths, weaknesses, opportunities, and threats, aiding in better decision-making for business growth. Agri-Business Opportunities, Technologies, Schemes, and Value Chain received a Relevancy Index of 68 per cent, indicating its relevance in providing insights into various opportunities and resources available for agribusiness ventures. How to Run a Small Enterprise scored 66.67 per cent, highlighting its usefulness in equipping agripreneurs with practical skills to manage small enterprises efficiently. However, Mobilization of Resources had the lowest Relevancy Index of 58.34 per cent, indicating that despite its importance in resource utilization, challenges at the local level may have limited its perceived relevance among trainees.

Entrepreneurial management phase

The Relevancy Index for topics in the Entrepreneurial Management phase demonstrates varied perceptions of their importance among trainees. Related Case Studies emerged as the most relevant, with the highest Relevancy Index of 79 per cent. This underscores the value of case studies in providing a comprehensive understanding of real-world scenarios, challenges, and solutions. Project Management followed with a Relevancy Index of 71 per cent, highlighting its importance in preparing for project execution and securing financial support such as loans. General Management: Principles & Practices (68.34%) and Agri-Business Management (67.34%) were rated as moderately relevant, emphasizing their role in understanding management practices and agribusiness operations. Legal Aspects – Agri Acts & Orders scored 64.67%, reflecting the necessity for agripreneurs to stay updated with evolving government regulations. Similarly, topics like Human Resource Development (64%) and Internet Practical (64%) were considered moderately relevant, showcasing their importance in skill development and digital competency. Farm Management scored 61.34%, emphasizing its role in organizing farm resources for sustainable and profitable operations. Basic Computer Skills (59%) were considered less relevant, as many agripreneurs operated traditional enterprises with minimal reliance on technology. Bookkeeping (56%) and Cash/Fund Flow (55%) had the lowest Relevancy Index scores, as record-keeping was less prioritized by some agripreneurs who managed small-scale operations or outsourced these tasks to accountants.

Entrepreneurial planning phase

The Relevancy Index for topics in the Entrepreneurial Planning phase highlights the varying importance of these components as perceived by the trainees. Exposure Visits stood out as the most relevant topic, with the highest Relevancy Index of 81 per cent, indicating their effectiveness in providing practical insights through real-life interactions and observations of sustainable practices. Project Identification by Trainees and Preparation was also highly valued, with a Relevancy Index of 70.67 per cent, reflecting the importance of structured problem identification and project planning for entrepreneurial success. Project Identification Presentation and Counseling followed with a score of 68.34 per cent, showcasing its significance in refining and presenting project ideas. The Type of Organization scored 67.34 per cent, emphasizing its role in helping trainees understand various enterprise models and make informed decisions. Source of Information: Enterprise Specific had a Relevancy Index of 63.34 per cent, reflecting its importance in gathering reliable and relevant data for enterprise planning. Topics such as Environment Scanning – Market Survey (57.34%) and Resource Analysis and Counseling (56.34%) were considered moderately relevant, indicating their utility in assessing external factors and resource utilization. However, Market Survey: Tools and Techniques (55.34%) and Market Survey: Report and Analysis (53.67%) had the lowest scores, likely due to the complexity of agricultural marketing and the advanced skills required to conduct and interpret such surveys effectively.

DISCUSSION

Table 1 highlights that during the entrepreneurial development phase, Communication Skills were deemed the most relevant, with a Relevancy Index score of 72.67 per cent. This was followed by Farmer Relationship Management (70.34%). Problem Solving was perceived as less relevant, with the lowest score of 54.34 per cent. The broader nature of problem-solving may have limited its practical applicability, whereas Communication Skills were valued for their role in reducing communication gaps, leading ventures, and creating market impact. While contrast result found by Chandrashekara et al., (2012) in his study entitled "Effectiveness of Training methods in Agri-clinics and Agri-business Centers" in which they revealed that communication had lowest relevancy score index of 61 per cent. Farmer Relationship Management and Networking were also seen as relevant, aiding in building customer relationships and boosting sales. Table shows that in the enterprise planning and resourcing phase, Enterprise Planning scored the highest at 78 per cent, followed by Experience Sharing by Successful Agripreneurs (75.34%) and SWOT Analysis. Mobilization of Resources was considered less relevant, scoring 58.34 per cent. The finding aligns with the result of Timmons & Spinelli (2010) in his study entitled "New venture creation: entrepreneurship for the 21st century" in which they recognized importance of effective planning in entrepreneurial success. Enterprise Planning aids decision-making and provides clarity across business aspects, while experience sharing offered insights into successful strategies. SWOT Analysis was valued as a framework for understanding strengths, weaknesses, opportunities, and threats, enhancing decision-making. Topics like managing small enterprises were seen as relevant for improving creativity and resource efficiency. However, resource mobilization was perceived as less effective due to challenges at the local level despite government efforts. Data reveals that in the entrepreneurial management phase, Related Case Studies scored the highest (79%), followed by Project Management (71%). Cash/Fund Flow was considered less relevant, with the lowest score of 55 per cent. Case studies provided a holistic understanding of entrepreneurship, while Project Management aided in loan preparation. Farm Management was relevant for organizing resources and ensuring profitability. Legal aspects, such as agriculture laws, were valued for compliance with changing regulations. Computer skills and bookkeeping were

less relevant, as many agripreneurs had traditional enterprises requiring minimal digital tools or hired accountants for record-keeping and loan proposals. Similar result found by Chandrashekar et al., (2012) in which the observed that 74 per cent perceived topic case study as most relevant. The entrepreneurial planning phase (agri-specific), Exposure Visits had the highest score (81%), followed by Project Identification and Preparation (70.67%). Exposure visits allowed trainees to engage with real-world sustainable practices, while project identification helped focus on challenges and opportunities for success. Topics like enterprise type and information sources were relevant for selecting suitable ventures and gathering enterprise-specific data. Market Survey (Report & Analysis) scored the lowest at 53.67 per cent. Market surveys were less relevant due to the complexities of agricultural marketing, which require specialized skills to navigate dynamic market conditions and contrast result found by Chandrashekar et al., (2012) in which they observed that interview with successful entrepreneurs have relevancy index score 74 per cent.

CONCLUSION

This study evaluates the training curriculum and methods employed by the nodal training institute of Varanasi for entrepreneurial training. The findings indicate that agripreneurs found the training methods effective, with practical exposure in the content perceived as more relevant and useful. However, topics like market studies and linkages scored lower on the relevancy index, highlighting a need for greater focus on market-related aspects crucial for enterprise establishment. The study also emphasizes the need for more enterprise-specific training tailored to agripreneurs' requirements. Overall, the training methods and content were deemed relevant and useful in fostering entrepreneurship among agricultural graduates. The findings suggest that the curriculum effectively develops entrepreneurial qualities but requires updates to address gaps, particularly in market-related training, to further enhance the success of the ACABC scheme.

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Research Article

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Impact of Soil Health Card on Urea Fertilizer Usage and Crop Yield in Haryana

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HIGHLIGHTS

- Farmers partially implement the recommendations of soil health card.
- Adoption of soil health card recommendations leads to a reduction in urea fertilizer usage.
- Reduction in usage of urea under soil health card recommendations does not result in lower crop yields.
- Adoption of soil health card recommendations does not cause financial loss.

ARTICLE INFO

Keywords: Soil health, Urea usage, Crop yield, Economic analysis, Haryana.

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ABSTRACT

Soil health is crucial for sustaining agricultural productivity. This study evaluates the impact of the Soil Health Card (SHC) scheme on fertilizer usage and crop yield in Haryana. Using primary data obtained from farm-level survey conducted utilizing a pre-tested semi-structured schedule in 2024–25, the research compares urea application and crop productivity between SHC adopters and non-adopters. The impact of SHC adoption on urea usage and yield varies across crops. The findings indicate that while SHC-adopting farmers apply urea at levels below conventional practices, they still exceed recommended doses. SHC adoption leads to a statistically significant reduction in urea usage, without compromising crop yields. An economic analysis reveals that paddy and wheat farmers benefit from both cost savings and increased yield. The study underscores the potential of SHC in promoting balanced fertilizer usage while maintaining crop yield. The novel findings support the need for implementation of tailored nutrient management strategies to safeguard soil health.

INTRODUCTION

Agriculture in Haryana predominantly relies on chemical fertilizers. The fertilizer consumption pattern has undergone considerable transformation during recent past across the regions (Shah et al., 2025). Fertilizer usage in the state is skewed towards urea (Aryal et al., 2021). One of the main drivers of excessive nitrogen fertilizer use is the perceived potential for higher crop yields (Reddy et al., 2024). However, maintaining soil health is critical for sustaining agricultural productivity in the long-run (Sheoran et al., 2024). The imbalanced use of chemical fertilizers has contributed to soil degradation, declining yields, and environmental concerns in the state (Mandal, 2024). Additionally, reducing chemical fertilizer usage has a notable positive externality by improving public health (Ai et al., 2024). Consequently, it is crucial to facilitate farmers for prudent use of chemical fertilizers. Governments are expected to incentivize such beneficial externalities. To this end, the Government of India (GOI) launched the Soil Health Card (SHC) Scheme in 2015. The initiative aims to promote judicious fertilizer use by providing farmers with a scientific assessment of soil health, enabling informed decisions on fertilizer application. Haryana has actively implemented the SHC scheme to improve agricultural sustainability (Ohlan et al., 2025).

Given the state's intensive cropping patterns and high fertilizer consumption, evaluating the SHC's impact on fertilizer usage and crop yield is essential. Regarding existing literature, it has been

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observed that a few studies have assessed the impact of SHC on fertilizer consumption pattern and farming profitability concerning mainly Uttar Pradesh (Sahay et al., 2019; Singh et al., 2023). Besides, the previous studies considered a very limited number of crops, mainly wheat and paddy. Most of these relevant studies pointed out the losses in crop yield due to existing excess use of nitrogen fertilizer. However, there is a lack of a compressive and systematic assessment of economic impact of SHC in the context of Haryana. Additionally, previous research has focused mainly on SHC adopters, overlooking a comparative analysis with non-adopters (Chouhan et al., 2017). Since fertilizer usage varies across states in India, it is essential to examine the impact of SHC across different regions using a comprehensive approach.

The objective of this study is to investigate impact of soil health card on urea fertilizer application and yields of major crops grown in Haryana. In this process, the study answers three research questions: Does the adoption of SHC influence urea fertilizer usage? Does SHC adoption lead to yield decline across different crops? and Does SHC adoption reduce economic benefits compared to non-adopters? By comparing urea usage and yield outcomes between SHC adopters and non-adopters, this research provides empirical insights into the scheme's economic impact. In this way, the findings contribute to the broader discourse on sustainable agricultural practices and policy interventions aimed at enhancing farm productivity while preserving soil health.

METHODOLOGY

This study analyzed the impact of implementing SHC recommendations on urea fertilizer usage and crop yield. To achieve its objective, the current study used an exploratory-cum-descriptive research design. It employed a mixed-method approach, integrating primary survey data on urea usage and crop yield with secondary data on minimum support prices and urea prices. The study included six major crops cultivated in the state. A pre-tested semi structured questionnaire was used to collect primary data through face-to-face quantitative surveys with individual farmers. A farm-level field survey was conducted in six districts, each specializing in a different crop: Karnal (wheat), Yamunanagar (sugarcane), Rewari (mustard), Kurukshetra (paddy), Sirsa (cotton), and Mahendragarh (bajra) during 2024–25.

To ensure adequate representation, the Cochran sampling formula (Potapov et al., 2022) was utilized, yielding a representative sample of 396 farmers at a 95 per cent confidence level with a 5% margin of error. Information on SHC adopters in select districts were gathered from soil health testing laboratories. A purposive sampling technique was used to determine survey locations, selecting one block with a high concentration of SHC adopting farmers from each select district. Three villages were then chosen from each selected block using the same method. Within each village, a list of SHC adopting farmers was compiled, from which 11 farmers were randomly selected. To mitigate the impact of soil fertility variations, cropping pattern and irrigation facilities on fertilizer use, an additional 11 farmers were randomly chosen for the control group from neighboring fields based on a separate list. Participation of farmers was voluntary, and their informed consent was obtained before the interviews.

The data on minimum support prices (MSP) of various crops under reference were taken from Agricultural Statistics at a Glance, annual publication of Ministry of Agriculture & Farmers' Welfare, Government of India. The data on urea price were obtained from Fertiliser Statistics, an annual publication of Fertiliser Association of India, Government of India. The mean comparison independent samples t-test was used to compare the per-acre urea fertilizer usage by SHC adopters and non-adopters (Khanna & Kaur, 2023). The economic analysis was conducted by comparing differences in per acre cost of urea and yield of crops under reference obtained by SHC adopters and non-adopters. The value of various crops was estimated based on their MSP, while the cost of urea was calculated at its retail market price (Ohlan, 2021).

RESULTS

Urea fertilizer usage vis-a-vis recommended dose

Table 1 presents the pattern of urea fertilizer usage, measured in terms of the estimated average quantity of SHC recommended and actual doses used by soil test farmers for major crops grown in Haryana. A review of data presented in Table 1 shows that farmers holding soil health cards apply a significantly higher quantity of urea than the recommended doses for all crops studied. For paddy, the recommended dose of urea for soil test farmers was 98 kg per acre, whereas they applied 110 kg per acre—an increase of 12.24 per cent. Similarly, for wheat, farmers used 10 kg per acre more urea than the recommended level. For mustard, sugarcane, bajra, and cotton, the application of urea exceeded the recommended levels by 8.70, 6.25, 5.26 and 6.25 per cent, respectively.

Table 1. Recommended and Actual Use of Urea Fertilizer in Haryana (kg/acre)

Crop	Recommended A	Actual B	Difference C = B-A	Percentage Gap D = (C÷A) ×100
Paddy	98	110	12	12.24
Wheat	95	105	10	10.53
Mustard	23	25	2	8.70
Sugarcane	160	170	10	6.25
Bajra	19	20	1	5.26
Cotton	80	85	5	6.25

Note: N= 198

Impact of SHC on urea fertilizer usage

It is pertinent to examine the impact of the SHC scheme on fertilizer usage. Table 2 presents the estimates for the use of urea fertilizer by control group farmers and soil test farmers of crops under study. The results of the mean comparison test (t-test) for the difference in average urea usage between treatment and control group farmers are statistically significant at the 1% level. This indicates that the adoption of SHC significantly reduces urea usage. Specifically, the impact of SHC adoption was found to be most pronounced in the cultivation of bajra, where urea usage declined by 20 per cent. Mustard cultivation followed closely, with a 16.67 per cent reduction in urea usage. In absolute terms, soil test farmers used 110 kg and 105 kg of urea per acre for paddy and wheat cultivation, respectively, whereas the control group farmers applied

Table 2. Use of Urea Fertilizer in Cultivation of Various Crops in Haryana (kg/acre)

Crop	Control Farmers A	Soil Test Farmers B	Difference C = B-A	Percentage D = (C÷A)×100	t-value
Paddy	125	110	-15	-12.00	9.66*
Wheat	120	105	-15	-12.50	9.21*
Mustard	30	25	-5	-16.67	12.2*
Sugarcane	180	170	-10	-5.56	14.72*
Bajra	25	20	-5	-20.00	15.06*
Cotton	90	85	-5	-5.56	8.08*

Note: * = Mean comparison independent samples t-test value is significant at 1% level.

125 kg and 120 kg per acre, respectively. SHC adopters used 15 kg per acre less urea in the cultivation of paddy and wheat. Additionally, SHC-adopting farmers reduced urea use in the cultivation of sugarcane and cotton by 5.56 per cent.

Impact of SHC on crop yield

To evaluate the economic impact of SHC adoption, it is essential to assess the effect of reduced urea usage on crop yield. Table 3 compares the crop yields of control farmers with those of soil test-based fertilizer application farmers. The yield levels of paddy and wheat for control group farmers were 1689 kg/acre and 2042 kg/acre, respectively, while the corresponding figures for soil test farmers were 1691 kg/acre and 2043 kg/acre. The yield attained by SHC adopters was slightly higher than that of control group farmers by 2 kg/acre for paddy and 1 kg/acre for wheat. For the remaining crops, the yield differences between control and soil test farmers were also minimal, ranging from 1 kg/acre for mustard to 3 kg/acre for sugarcane. In sum, there is no considerable yield loss due to less application of urea.

Table 3. Yield of Various Crops in Haryana (kg/acre)

Crop	Control Farmers A	Soil Test Farmers B	Difference C = B-A
Paddy	1689	1691	2
Wheat	2042	2043	1
Mustard	785	784	-1
Sugarcane	33045	33042	-3
Bajra	996	994	-2
Cotton (Lint)	184	182	-2

Comparative economic analysis

Table 4 presents the economic analysis of the impact of SHC adoption by considering the reduction in urea costs, changes in the value of crop output, and the resulting net profit or loss (Rs/acre) across six major crops in Haryana. SHC adoption led to a reduction in urea costs by Rs. 80.7/acre for both paddy and wheat. At the same time, the value of output increased by Rs. 46/acre for paddy and Rs. 23/acre for wheat. This resulted in a net profit of Rs. 126.7/acre for paddy and Rs. 103.7/acre for wheat.

A mixed impact was observed in case of cultivation of sugarcane. Farmers saved Rs. 53.8/acre in urea costs but experienced a decline of Rs. 12/acre in output value. Despite this, they achieved a net profit of Rs. 41.8/acre. Although SHC adoption reduced urea costs by Rs. 26.9/acre for mustard, bajra, and cotton, the value of output declined by Rs. 57/acre for mustard, Rs. 53/acre for bajra, and Rs. 142/acre for cotton. Consequently, slight net losses were recorded at Rs. 30.1/acre for mustard, Rs. 26.1/acre for bajra, and Rs. 115/acre for cotton.

Table 4. Economic Impact of SHC in Haryana (Rs/acre)

Crop	Reduction in Cost of Urea A	Change in Value of Output B	Net gain/ Loss C = A+B
Paddy	80.7	46	126.7
Wheat	80.7	23	103.7
Mustard	26.9	-57	-30.1
Sugarcane	53.8	-12	41.8
Bajra	26.9	-53	-26.1
Cotton	26.9	-142	-115

DISCUSSION

The comparative analysis revealed that the actual usage of urea in all crops under reference was higher than their recommended levels, ranging from 5.26 per cent to 12.24 per cent. This indicates a strong tendency among farmers to rely on conventional fertilization practices, possibly due to ingrained habits or misconceptions about optimal nutrient application. This finding aligns with Patel et al., (2023), who observed similar behavior among cereal cultivators in Bihar, where farmers did not fully adhere to tailored fertilizer recommendations despite adopting SHC practices. Similar trends have been reported by Grover et al., (2016), who found that farmers in Punjab and Uttar Pradesh often overuse urea due to a lack of awareness about balanced nutrient management and the perceived immediate benefits of nitrogen-based fertilizers.

The analysis further highlighted the effectiveness of SHC in promoting judicious fertilizer use. SHC adopters demonstrated significant reductions in urea usage compared to non-adopters, with the highest reductions observed in bajra (20%) and mustard (16.67%). Paddy and wheat farmers also reduced urea usage by 12-12.5 per cent. These reductions underscore SHC's potential to improve soil health and foster more sustainable fertilizer management practices. It also emphasized that SHC-based recommendations help optimize fertilizer use, thereby enhancing nutrient use efficiency and reducing environmental degradation. These findings are consistent with those of Singh et al., (2023), who reported a 15-25 per cent reduction in urea usage among SHC adopters in Sulphur, Uttar Pradesh, leading to improved soil organic carbon levels and reduced nitrogen leaching. The low-dose urea use

not only improves crop quality but also indirectly benefits public health (Das et al., 2022).

The findings suggest that conventional fertilization practices, which often involve excessive urea use, do not necessarily lead to substantial yield gains compared to soil test-based fertilizer application. The lower yields of wheat and paddy among non-adopting farmers (control group) may be attributed to lodging caused by excessive fertilizer application during final irrigation or rainstorms (Tripathi et al., 2023). The findings imply that current fertilizer practices may not be optimal in terms of nutrient application, and reducing urea usage can maintain yields at par with conventional methods. This finding lends support to Ankhila et al., (2021), who found that SHC based nitrogen application in paddy led yield gain in Andhra Pradesh.

An economic assessment of SHC adoption further highlights its benefits. Paddy and wheat farmers experienced both cost savings and increased output value, resulting in net profits of Rs. 126.7/acre and Rs. 103.7/acre, respectively. Sugarcane farmers also benefited from reduced urea costs, though they saw a slight decline in output value, still achieving a positive net return. However, the economic impact varied for mustard, bajra, and cotton farmers, who recorded small net losses due to reduced output values outweighing urea cost savings. The economic analysis presented by Panda et al. (2022) about fixed and operational cost, gross return with or without dividend and benefit cost ratio also advocates reduction of operational cost for higher dividends. These findings are in line with Grover et al., (2016), who reported that SHC adoption led to significant cost savings for paddy and wheat farmers in Punjab.

Overall, the results indicate that SHC adoption had varying economic effects across different crops in Haryana. While paddy and wheat farmers reaped significant benefits, mustard, bajra, and cotton farmers experienced minimal losses, suggesting that SHC-based fertilizer recommendations did not lead to lower financial returns. These findings emphasize the need for further extension efforts to ensure farmers fully understand and trust soil health-based fertilization practices. In sum, while SHC adoption effectively reduces excessive urea use without compromising yields, its economic impact varies across crops, highlighting the importance of tailored approaches for different agricultural contexts. Regarding the societal importance of the findings, adopting low-dose urea application practices can contribute to safer, more nutritious food and support sustainable agricultural systems, which are critical for addressing pressing public health and environmental challenges in India. The government and non-government organizations can provide incentives to farmers to reduce urea fertilizer usage in food crops (Zheng et al., 2022). The analysis of variations in the cost structure of various crops between adopters and non-adopters of SHC using a causal research design presents a promising avenue for future research.

CONCLUSION

This study analyzed the impact of the soil health card scheme on urea usage and crop yield levels in Haryana. The findings reveal that soil test farmers generally apply higher-than-recommended doses of urea across major crops. The evaluation of SHC adoption shows a statistically significant reduction in urea usage among soil test farmers compared to control group farmers, demonstrating the scheme's effectiveness in promoting judicious fertilizer application. Despite the reductions in urea application, yield levels for SHC-adopting farmers remained largely unchanged or showed marginal improvements across all crops. This suggests that excessive urea application does not necessarily translate into higher productivity and that balanced fertilization based on soil testing is sufficient for maintaining crop yields. Overall, the findings indicate that SHC adoption not caused economic losses to farmers. Moving forward, policymakers should focus on strengthening awareness programs to enlarge the adoption of SHC scheme in Haryana.

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Research Article

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Food, Economic, and Livelihood Security of Farmers under PMFBY in Kolar, Karnataka

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HIGHLIGHTS

- PMFBY beneficiaries demonstrated better livelihood security than non-beneficiaries in Kolar, Karnataka.
- Beneficiaries achieved greater economic stability and food security through PMFBY.
- Delayed insurance payouts remained a concern for non-beneficiaries.

ARTICLE INFO

Keywords: Livelihood security, Food security, Economic security, PMFBY, Agricultural Insurance, Crop insurance and farmers welfare.

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ABSTRACT

Indian agriculture faces multiple risks that threaten farmers livelihoods. The Pradhan Mantri Fasal Bima Yojana (PMFBY) was introduced to mitigate these risks through crop insurance. This study evaluates the impact of PMFBY on the food and economic security of farmers in Kolar district, Karnataka, during 2021–2022. A total of 200 farmers (150 beneficiaries, 50 non-beneficiaries) were surveyed across five taluks. Food and economic security were assessed using specific indicators. Findings indicate that PMFBY beneficiaries experienced slightly better livelihood security than non-beneficiaries. Beneficiaries prioritized year-round food access (mean: 4.63), while non-beneficiaries relied more on the adequacy of Public Distribution System (PDS) grains (mean: 4.48). Economic security was primarily associated with optimal resource utilization (beneficiaries: 4.61; non-beneficiaries: 4.52). Overall, 53.5 per cent of beneficiaries reported improved food security and 57 per cent experienced enhanced economic stability. The results suggest a modest positive impact of PMFBY on farmer resilience. However, challenges such as delayed insurance payouts and awareness gaps persist. Strengthening implementation, improving claim processing, and increasing outreach efforts could enhance the scheme's effectiveness. Continuous evaluation is essential to optimize PMFBY's role in promoting sustainable agricultural livelihoods.

INTRODUCTION

India's agrarian economy is a cornerstone of its rural livelihood system, supporting millions who depend on agriculture for sustenance. Agriculture, being an open-field activity, is directly affected by climate change and is also the most vulnerable to this query (Saxena & Kumar, 2019). However, this sector faces significant vulnerabilities due to recurrent natural calamities such as droughts, floods, and unseasonal rainfall (Kumar & Swami, 2021). These events often result in devastating crop losses, adversely affecting farmers' incomes and their ability to secure credit for subsequent cropping seasons (Ghosh et al., 2021; Todmal, 2022; Birthal & Hazrana, 2019). This cyclical vulnerability underscores the pressing need for effective mechanisms to protect farmers' livelihoods and foster resilience (Dev & Mahajan, 2020). In February 2016, the Government of India introduced the Pradhan

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Mantri Fasal Bima Yojana (PMFBY), a comprehensive crop insurance scheme designed to mitigate agricultural risks and provide financial security to farmers. The PMFBY replaced earlier initiatives like the National Agricultural Insurance Scheme (NAIS) and Modified NAIS, addressing their limitations with a streamlined, farmer-centric approach. The scheme offers subsidized premiums-2 per cent for Kharif crops, 1.5 per cent for Rabi crops, and 5 per cent for annual commercial and horticultural crops-ensuring affordability and encouraging broader participation. Initially mandatory for loanee farmers, the scheme was made optional from Kharif 2020, providing farmers greater autonomy in decision-making (Ministry of Agriculture & Farmers Welfare, 2020; Sharma, 2021). The PMFBY seeks to stabilize farmers' income by mitigating crop losses caused by natural calamities, pests, and diseases. It also aims to promote modern agricultural practices by reducing the financial risks associated with experimentation. Moreover, the scheme facilitates credit flow to the agricultural sector, enhancing food security, promoting crop diversification, and fostering economic growth (Desai et al., 2022; Kumar et al., 2020). Despite these ambitious objectives, its implementation has encountered challenges such as delayed claim settlements, low awareness among farmers, and inconsistent regional outcomes (Nain et al., 2017; Meena et al., 2021; Kumar et al., 2023). Given the PMFBY's national importance and potential to impact rural livelihoods, localized research is essential for understanding its effectiveness. While existing studies provide broad overviews of the scheme's implementation, detailed regional analyses are scarce, particularly in Karnataka. This state, with its diverse agricultural landscape and varying levels of vulnerability, offers a valuable context for evaluating the PMFBY's impact. This study aims to address the gap by conducting a comparative analysis of PMFBY beneficiaries and non-beneficiaries in Karnataka, focusing on their levels of food and economic security. By examining these dimensions, the research seeks to provide deeper insights into the scheme's outcomes and its role in enhancing livelihood resilience at the grassroots level.

METHODOLOGY

This study employed a quantitative research approach to assess the implementation and effectiveness of the Pradhan Mantri Fasal Bima Yojana (PMFBY) and identify barriers to its operationalization. The research was conducted in Kolar district, Karnataka, during the 2021–2022 fiscal year. Kolar was purposively selected due to its diverse farming systems, progressive agricultural practices, and suboptimal PMFBY utilization within the Eastern Dry Zone-5, making it a suitable case for evaluating the scheme's adoption and impact. A multi-stage random sampling method was used to ensure representativeness. From each of Kolar's five taluks, 30 PMFBY beneficiaries and 10 non-beneficiaries were randomly selected, yielding a total sample of 200 farmers (150 beneficiaries, 50 non-beneficiaries). This sample size was determined based on prior studies on agricultural schemes, ensuring adequate statistical power for meaningful comparisons (Desai et al., 2022; Meena et al., 2021). A semi-structured questionnaire was developed to align with PMFBY objectives. The questionnaire included indicators related to food security (year-round access, affordability, nutritional adequacy) and economic security (income stability, savings, risk mitigation). Questionnaire validity was ensured through expert validation from agricultural economists and extension professionals. Data were analyzed using IBM SPSS 26.0. Descriptive statistics (mean, standard deviation, percentages) summarized livelihood security indicators. A Two-sample z-test for proportions was used to assess significant differences in food and economic security between beneficiaries and non-beneficiaries. The z-test was chosen as it effectively compares proportions between independent groups (Kumar et al., 2023) and is appropriate for large sample sizes with categorical outcomes, unlike t-tests, which are suited for continuous variables.

Food security of livelihood in present study is defined as the condition where individuals have reliable access to sufficient quantities of affordable, nutritious food to lead a healthy life secured through participation in the PMFBY scheme, whereas, the economic security of livelihood is the degree to which the farmers have monetary stability between income, expenditure and savings at a given point of time protected through participation in the PMFBY scheme. Similarly, livelihood security**,** is operationally defined as the extent of livelihood security derived by the farmers through enrollment/participation into PMFBY scheme in terms of food, social, economic, and psychological securities so as on to protect their capabilities, assets, and activities which are essential for their livelihood.

RESULTS

The analysis of livelihood security among both beneficiaries and non-beneficiaries is presented in Tables and Figures. The results indicate that a significant proportion of beneficiaries exhibited higher levels of livelihood security across various elements, as reflected in the individual statements. Conversely, the majority of non-beneficiaries showed a lack of awareness, possibly due to their limited interest in the PMFBY scheme. Regarding food security, distinct differences emerged between PMFBY beneficiaries and non-beneficiaries (Table 1). Beneficiaries placed the highest value on the consistent "availability of food throughout the year," achieving a mean score of 4.63, indicating a strong sense of food security. They also highly rated the "adequacy of food grains provided through the public distribution system" (mean score: 4.59), suggesting that even with insurance coverage, the PDS remains an essential component of their food security strategy. In contrast, non-beneficiaries prioritized "adequacy of food grains provided through the public distribution system" as their primary source of food security, with a mean score of 4.48. While they also valued "availability of food throughout the year" and "affordability of providing balanced food to family members," these aspects received slightly lower mean scores of 4.44. This suggests that non-beneficiaries rely more heavily on government-provided food resources and may face greater challenges in ensuring consistent access to diverse and nutritious food.

Concerning economic security, both beneficiaries and non-beneficiaries recognized the importance of "optimal utilization of economic resources by the farming system adopted." Beneficiaries, however, demonstrated a higher mean score of 4.61, suggesting that participation in PMFBY enables them to manage their resources more effectively, likely due to reduced financial risks associated with

Table 1. Assessment of Food Security Among PMFBY Beneficiary and Non-beneficiary Farmers

S.No.	Statements	Beneficiaries (n1=150) Mean Score	Non-Beneficiaries (n=50) Mean Score
1	Food in some kind is available for me throughout the year	4.63	4.44
2	Food grains provided through public distribution system is adequate in meeting food & nutritional security of my family.	4.59	4.48
3	Providing balanced food to family members is affordable for me	4.49	4.44
4	The quality of food available to my family is good	4.36	4.08
5	The farming system adopted by me provides a broad range of food items for my family	4.35	4.16
6	The quantity of the food items consumed by the household members is insufficient for physiological needs	2.69	3.14

crop losses. They also placed importance on "the possibility of making reasonable savings from farm earnings given their farming conditions" (mean score: 4.56), implying that PMFBY contributes to their financial stability and ability to save. Non-beneficiaries, while also valuing optimal resource utilization (mean score: 4.52), prioritized "assurance of higher income generation through marketing of various produces in different seasons given their farming condition" as their second most important aspect of economic security (mean score: 4.50). This suggests that non-beneficiaries focus more on direct income generation through market activities as a means of achieving economic security, potentially due to the absence of the financial buffer provided by PMFBY(Table 2).

Examining overall livelihood security, a notable disparity emerged between the two groups. A significant proportion of beneficiaries (51.30%) reported "better" food security towards the PMFBY scheme, while only 14 per cent of non-beneficiaries reported the same. Conversely, a substantial majority of non-beneficiaries (70%) reported "poor" food security towards the PMFBY scheme, compared to only 19.30 per cent of beneficiaries. Similarly, in terms of economic security, 48 per cent of beneficiaries

Table 2. Itemized Assessment of Economic Security among PMFBY Beneficiary and Non-beneficiary Farmers

S.No.	Statements	Beneficiaries (n1=150) Mean Score	Non-Beneficiaries (n=50) Mean Score
1	The farming system adopted by me optimally utilizes my economic resources	4.61	4.52
2	With my farming condition it is possible to make reasonable savings out of farm earnings	4.56	4.18
3	My farm provides variety of income from products of agriculture and allied enterprises	4.47	4.28
4	My farm enables me efficient utilization of land	4.39	4.34
5	My farm enables to get higher benefit- cost ratio possible	4.45	4.30
6	My farming condition assures higher income generation through marketing of various produces in different seasons	4.44	4.50
7	Overcoming financial stress condition is prevailing with my farming situation	4.43	4.24
8	My farm conditions adequately protects me against risk and uncertainties of farming	4.41	4.34
9	In my farm I am able to achieve maximum farm productivity and income	4.33	4.10
10	Components of my farming system doesn't stabilize my farm income (-)	2.80	3.44

Table 3. Overall food security and economic security status of farmers under the PMFBY scheme

	Beneficiary (n_1= 150) (%)	Non-Beneficiary (n_2= 50) (%)	Overall (n=200) (%)
Category (Food security)			
Poor (<180.13)	19.30	70.00	32.00
Average (180.13-193.87)	29.30	16.00	26.00
Better (>193.87)	51.30	14.00	42.00
	Mean = 186.47	Mean = 176.84	Mean=187.05
	SD = 10.23	SD = 18.98	SD = 13.75
	Z value = 3.427**		
Category (Economic security)			
Poor < 144.40	22.70	66.00	33.50
Average 144.40-156.68	29.30	26.00	28.50
Better >156.68	48.00	8.00	38.00
	Mean = 146.49	Mean = 143.78	Mean = 150.54
	SD = 6.81	SD = 20.35	SD = 12.28
	Z value = 3.227**		

reported "better" economic security, whereas only 8 per cent of non-beneficiaries did so. A large majority of non-beneficiaries (66%) reported "poor" economic security compared to 22.7 per cent of beneficiaries (Table 3). These findings indicate that PMFBY participation is strongly associated with improved perceptions and experiences of both food and economic security.

DISCUSSION

This study assessed the impact of the Pradhan Mantri Fasal Bima Yojana (PMFBY) on food security, economic stability, and overall food & economic security among farmers in Kolar district, Karnataka. The findings highlight significant differences between PMFBY beneficiaries and non-beneficiaries, providing critical insights into the scheme's effectiveness and broader implications for rural livelihoods. The results indicate that PMFBY beneficiaries experience a statistically significant improvement in food security compared to non-beneficiaries ($p < 0.05$). Beneficiaries reported greater assurance of year-round food availability, suggesting that crop insurance enhances their ability to maintain consistent food access. This finding aligns with previous studies emphasizing the role of agricultural insurance in stabilizing farm incomes and reducing vulnerability to food insecurity (Mehrabi et al., 2022; Diao & Pratt, 2007; Rose & Charlton, 2001). Additionally, the study highlights the complementary role of the Public Distribution System (PDS) in supporting food security. While both groups rely on PDS, beneficiaries appear to strategically utilize this safety net, indicating that agricultural insurance and food assistance programs work synergistically (Mehrabi et al., 2022; Shwetha et al., 2021). In contrast, non-beneficiaries exhibit higher dependence on PDS due to financial constraints, underscoring the persistent food insecurity risks faced by uninsured farmers. These findings reinforce the importance of expanding insurance coverage to a broader segment of farmers and ensuring better accessibility to both insurance and food security programs.

The study further demonstrates that PMFBY contributes to economic stability by enabling beneficiaries to engage in effective financial planning and resource management. Beneficiaries prioritized "optimal utilization of economic resources" and "reasonable savings," reflecting an increased capacity for long-term investments in farming. This finding is consistent with prior research highlighting the role of agricultural insurance in improving risk management and resource efficiency among farmers (Jabbar et al., 2020; Tiwari et al., 2020; Shwetha et al., 2022). Moreover, by mitigating financial risks associated with crop failures, PMFBY provides greater confidence to farmers in making investment decisions and adopting modern farming practices. The psychological benefits of financial security, including reduced stress and improved mental well-being, have been well-documented in the literature (Agarwal et al., 2022; Tiwari et al., 2020). However, non-beneficiaries focus more on direct market engagement and income generation through agricultural marketing, which, although crucial, makes them more vulnerable to market price fluctuations and income instability. These insights suggest that while PMFBY plays a vital role in enhancing financial resilience, additional efforts should be made to expand coverage and integrate financial literacy programs for non-beneficiaries.

Overall, the study reinforces the positive association between PMFBY participation and improved livelihood security of food and the economy. Beneficiaries consistently report higher levels of food and economic security, which enhances their overall well-being and resilience. These findings are in line with previous research suggesting that agricultural insurance schemes serve as crucial tools for reducing livelihood risks and fostering sustainable farming systems (Shwetha et al., 2021; Patel et al., 2021). Despite these benefits, key challenges in PMFBY implementation remain, including gaps in insurance coverage, delays in claim settlements, and low farmer awareness. Addressing these issues through policy refinements—such as streamlining claim processing, improving outreach programs, and integrating PMFBY with broader rural development initiatives—can significantly enhance its impact on farmer resilience. Strengthening institutional mechanisms and ensuring timely reimbursements will be crucial for maximizing the effectiveness of agricultural insurance in improving farmer welfare.

CONCLUSION

The study revealed key differences between beneficiaries and non-beneficiaries. Beneficiaries showed significantly higher levels of both food and economic security, demonstrating the scheme's effectiveness in mitigating crop loss impacts. While non-beneficiaries relied more on the PDS and other income sources, PMFBY provided a financial safety net for beneficiaries, improving resource management and food access. These findings emphasize the need to promote PMFBY adoption, especially among vulnerable farmers. The study also highlights the importance of a combined approach to yield estimation in diverse cropping systems like Kolar's, balancing accuracy, coverage, and trust. Ensuring timely reimbursements is crucial for enhancing farmer well-being and resilience. This research contributes to agricultural economics by providing regional empirical evidence of PMFBY's impact on livelihood security, informing policy decisions for stronger agricultural risk management and improved farmer welfare.

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Research Article

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Training Needs of Fish Farmers for the Development of Fisheries and Aquaculture in Meghalaya

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HIGHLIGHTS

- Key training needs include aquaculture, hatchery management, disease control, fish seed production, value addition, and pond construction.
- Higher income and information access drive demand for advanced fisheries training.
- Farmers with larger ponds and more experience perceive less need for further training.

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ABSTRACT

The study assessed the training needs of fish farmers in the West Garo Hills and Ri-Bhoi districts of Meghalaya from the data collected with pre-tested semi-structured interview schedule from a randomly selected sample of 90 respondents from eight villages across four blocks. Training needs were prioritised using the Training Need Index (TNI). The study revealed that the majority of respondents were middle-aged (71.11%), had a secondary school education (37.78%), belonged to nuclear families (48.89%), and had up to 5 years of experience in fish farming (80%). Most respondents earned an annual income of up to ₹ 50,000 from fish farming (83.33%). The top areas of need were aquaculture (TNI 100.00), hatchery management, fish seed production, nursery management (TNI 97.03), and disease prevention and control in fish (TNI 96.29). Other needs included fish processing (TNI 70.00), pond construction and equipment management (TNI 62.2), recreational fisheries (TNI 56.59), and communication tools for fish farmers (TNI 48.51). The key training requirements were carp culture, broodstock maintenance and breeding, fish disease management, value addition, hatchery construction, recreational pond development, and leveraging social media for information sharing. These findings emphasise the need for targeted training programmes to enhance fish production and productivity.

INTRODUCTION

Fisheries is a significant sector in India, providing food security and income for approximately 16 million people engaged in part-time or full-time activities (Fisheries Statistics, 2023). Meghalaya, one of India's Northeastern states, lies between 25°34'12" N latitude and 91°52'47" E longitude. The state is rich in biodiversity and inland fisheries resources, including rivers, reservoirs, lakes, and ponds. The annual rainfall of 1200 mm in the state offers tremendous potential for the development of fisheries by efficient fisheries resource management and conservation (Lahiri et al., 2024). The predominantly hilly terrain limits fish farming, resulting in a local fish production of 0.019 million tonnes (mt) in 2022–23, with a per capita fish consumption of 10.3 kg. The state's fish production is yet to match the domestic demand. Hence, the state still relies on fish imports from Andhra Pradesh, West Bengal, and Assam to meet its demand (Fisheries Statistics, 2023). Thus, it is essential to adopt scientific fish production practices by the

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fish farmers in the state to increase production and productivity, which can be achieved through need-based training and capacity building of the fish farmers in scientific fish farming practices.

Targeted training and capacity-building programmes are essential to equip fish farmers with the skills needed to increase production and improve livelihoods. Training helps enhance competencies, skills, and capabilities, thus enabling farmers to adopt improved practices and explore entrepreneurial opportunities (Jaiswal et al., 2019). Effective training requires a thorough needs assessment, addressing aspects like who needs training, what content is essential, and how it should be delivered (Pholonngoe & Richard, 1995; Nain & Kumar, 2001; Barbazette, 2006; Sajeev et al., 2012; Paul et al., 2015; Raina et al., 2017). Moreover, it is important to evaluate training effectiveness by measuring its alignment with goals and the successful transfer of knowledge and skills (Kumar et al., 2021). Training should emphasise the adoption of tacit knowledge for sustainable outcomes (Sajeev & Singha, 2010; Alabi & Ajayi, 2013; Pandey et al., 2015; Lahiri et al., 2024). Training Needs Assessment (TNA) is crucial for identifying suitable strategies, determining participants, and tailoring content to improve performance (Bhagat & Nain, 2005; Clarke, 2012). Approximately 30% of Meghalaya's total land area of 22,429 km^2 holds potential for fisheries development. Factors like limited job opportunities, availability of resources, and changing dietary preferences have increased interest in fisheries (MSAM, 2018).

Ri-Bhoi district, contributing 20% of the state's pond and mini barrage area, has an annual production potential of 1398 t. Similarly, West Garo Hills, the state's largest district, holds 24% of Meghalaya's wetland area (7,196 ha) and produced 0.221 million fish seeds in 2014–15 (Bhalerao et al., 2015). Assessing training needs optimises time and resources, fosters participation, and strengthens fisheries production (Kumar et al., 2024). Policymakers should prioritise need-based strategies to empower fish farmers and promote sustainable fisheries development in Meghalaya (Lahiri et al., 2020; Sajeev et al., 2021).

METHODOLOGY

The study was conducted in the Ri-Bhoi and West Garo Hills districts of Meghalaya. These two districts were purposively selected due to their significant fish farming activities. Within each district, two blocks were chosen based on the density of fish farmers: Umling and Umsning blocks in the Ri-Bhoi district and Rongram and Dadengre blocks in the West Garo Hills. Eight villages (two per block) were identified from the selected blocks, ensuring a diverse representation of fish farmers engaged in various aquaculture practices. The final sample consisted of 90 respondents, selected by a simple random sampling method, comprising small-scale fish farmers actively involved in fish farming. A semi-structured interview schedule was developed, and pre-tested to ensure the clarity, reliability, and validity of responses. Data collection was conducted through personal interviews and field visits to fish farms and households. Primary data was obtained directly from the respondents, while secondary data was collected from government reports, extension bulletins, research articles, and other relevant sources related to aquaculture development in Meghalaya. The Training Need Index (TNI) was calculated using the actual-to-maximum score method to systematically identify and prioritise the specific training needs of fish farmers. The index provided a quantitative measure to prioritise the levels for different training areas based on farmers' responses. The TNI was computed using the following formula:

$$\text{Training Need Index (TNI)} = \frac{\text{Total Score Obtained}}{\text{Maximum Obtainable Score}} \times 100$$

Higher TNI values indicate a greater demand for training in specific areas. The study identified seven key training domains based on experts' opinions relevant to the fish farmers of Meghalaya. The seven identified domains were aquaculture, fish product processing, disease prevention and control, hatchery management (including fish seed production and nursery operations), pond construction and equipment handling, recreational fisheries, and communication tools for fish farmers. Pearson's correlation coefficient (r) was applied to analyse the relationship between the training needs (dependent variable) and various independent variables, including farmers' age, education level, farm size, years of experience, and access to extension services. t-test was conducted to test the significance of the correlation coefficient.

RESULTS

Dynamics of training needs of the fish farmers

The adoption of fish farming among respondents is influenced by multiple factors, including age, education, family structure, pond size, experience, occupation, income, training, access to information, social participation, and extension contact. As shown in Table 1, the overall training need index (TNI) of fish farmers in the study area is 75.56, indicating a substantial requirement for training across various subject areas. Among these, aquaculture ranked highest (TNI 100, I), highlighting its critical importance. This was followed by hatchery management, fish seed production, and nursery management (TNI 97.03, II). Disease prevention and control in fishes (TNI 96.29, III) ranked third. Other key training areas included fish product processing (TNI 70, IV), pond construction and management, fish farming, and fishing equipment management (TNI 62.22, V). Recreational fisheries (TNI 56.29, VI) and communication tools for fish farmers (TNI 48.51, VII) were also identified as training priorities, albeit with relatively lower demand.

From Table 2, it is observed that under aquaculture and its allied sector, the *culture of carps* (TNI 96.29, I) emerged as the most needed training followed by the *composite culture of fishes* (TNI 95.92, II); *culture of other economic and commercial fish species* (TNI 95.18, III); *management during pre-stocking and post stocking of fishes* (TNI 93.70, IV); *pond handling and management* (TNI 93.33, V) and *management techniques of fish farms* (TNI 92.59, VI). *Rearing of locally available fish species* (TNI 33.17. XI) scored the least among the different training needs identified under Aquaculture. Training needs in the Processing of Fish Products revealed that fish farmers mostly require training in the *value addition of fish products* (TNI 71.48, I) as the most processed fish products, fermented and dry fishes, were imported from other

Table 1. Major areas of training needs of the fish farmers

S. No.	Major areas of training needs	Training Need Index (TNI)	Rank
1.	Aquaculture	100.00	I
2.	Processing of fish products	70.00	IV
3.	Disease prevention and control in fishes	96.29	III
4.	Hatchery management, fish seed production, and nursery management	97.03	II
5.	Pond construction, management of fish farming and fishing equipment	62.22	V
6.	Recreational fisheries	56.29	VI
7.	Communication tools for fish farmers	48.51	VII
	Overall Training Need Index	75.76	

states. This was followed by the *various methods of preservation of fish products* (TNI 65.92, II), *methods of packaging* (TNI 62.22, III), *various methods of fish drying* (TNI 50.37, IV) and *processing of fish by-products* (TNI 41.85, V).

Fish farmers identified *remedial measures for common fish diseases* (TNI 97.77, I) as the most critical training need, particularly due to the prevalence of diseases like epizootic ulcerative syndrome (EUS) and their lack of scientific knowledge to manage them. Other key training areas included the *identification of factors causing fish diseases* (TNI 96.67, II), *mitigation and treatment of polluted water in fish ponds* (TNI 95.18, III), and *soil and water quality management* (TNI 90.37, IV). Fish farmers prioritized the *maintenance and breeding of brooders* (TNI 97.03, I) as the most essential training area. This was followed by the *nursery and rearing of fish seeds* (TNI 96.67, II) and the *development of low-cost local hatcheries* (TNI 92.22, III). Other training needs included *packaging and transportation of fish seed* (TNI 89.25, IV) and *utilisation and maintenance of plastic hatcheries* (TNI 78.51, V), which ranked lowest, likely due to cost concerns. The highest-ranked training need was *hatchery construction* (TNI 76.29, I), reflecting a strong interest in fish seed production. Other key areas included *scientific fish farm construction* (TNI 68.51, II), while *construction and repair of indigenous fishing equipment* (TNI 48.14, III) ranked third. Training in the *operation and management of modern fishing equipment* (TNI 41.18, IV) had the lowest demand, as farmers viewed modern equipment as expensive and complex to operate. Many fish farmers in Meghalaya lease ponds for sport fisheries, particularly angling (Sangma et al., 2025). The top training need was the *construction of recreational ponds* (TNI 76.29, I), followed by the *selection of fish species for sport fishing* (TNI 68.51, II) and the *selection and utilisation of angling gears* (TNI 41.48, III). The *construction of fish parks and sanctuaries* (TNI 14.14, IV) had the least demand due to concerns about financial viability. The most preferred training area was the *use of social media for information sharing* (TNI 57.40, I), as platforms like Facebook and WhatsApp help farmers connect with peers and customers. Other training needs included *mobile applications for fish farmers* (TNI 43.70, II), *e-Agriculture initiatives* (TNI 35.80, III), and *ICTs in fisheries* (TNI 35.80, III). *Usage of KVK/Farmers' Portal* (TNI 34.81, IV) ranked lowest due to limited awareness and guidance.

Table 2. Training needs of fish farmers under different sub-domains (n=90)

Major areas of training needs of the fish farmers	Training Need Index (TNI)	Rank
Aquaculture		
Pond handling and management	93.33	V
Composite culture of fishes	95.92	II
Culture of carps	96.29	I
Culture of other economic and commercial fish species	95.18	III
Management during pre-stocking and post-stocking of fishes	93.70	IV
Management techniques of fish farms	92.59	VI
Integrated farming	88.14	VII
Breeding of ornamental fishes	35.18	IX
Rearing of locally available fish species	33.17	XI
Fabrication of aquarium	34.44	X
Feed preparation	68.89	VIII
Processing of Fish Products		
Value addition of fish products	71.48	I
Various methods of fish drying	50.37	IV
Methods of packaging	62.22	III
Processing of fish by-products	41.85	V
Methods of preservation of fish products	65.92	II
Disease Prevention and Control		
Remedial measures of common fish diseases	97.77	I
Identification of different factors causing fish diseases	96.67	II
Mitigation and treatment of polluted water in fish farmers' ponds	95.18	III
Soil and water quality management	90.37	IV
Hatchery Management, Fish Seed Production & Nursery Management		
Development of low-cost local hatcheries	92.22	III
Nursery and rearing of fish seeds	96.67	II
Maintenance and breeding of brooders	97.03	I
Utilisation and maintenance of plastic hatcheries	78.51	V
Process of packaging and transportation	89.25	IV
Pond Construction and Management of Fish Farming/Fishing Equipment		
Fish farm construction	68.51	II
Construction of hatcheries	76.29	I
Construction and repairing of indigenous fishing equipment	48.14	III
Operation and management of modern fishing equipment	41.48	IV
Recreational Fisheries		
Types of fish species stocked for sport fishing in ponds	68.51	II
Selection and utilisation of fishing/angling gears	41.14	III
Construction of recreational ponds	76.29	I
Construction of fish parks and sanctuary	41.48	IV
Communication tools for fish farmers		
Mobile applications for fish farmers	43.70	II
Usage of KVK/Farmers' Portal	34.81	IV
Use of social media for information sharing	57.40	I
e-Agriculture initiatives	35.18	III
ICTs in Fisheries	35.18	III

Relationship between the training needs (dependent variable) and various independent variables

Table 3 shows that annual income and access to information sources exhibit a significant positive correlation with training needs, whereas pond area and fish farming experience show a significant negative correlation. Similarly, Anshuman et al., (2024) highlighted the importance of delivering essential information to boost farmers' productivity. Fish farmers with smaller pond areas often lack the necessary resources and knowledge to engage in fish farming, increasing their need for training programmes. These findings indicate that training needs are directly influenced by annual income, access to information sources, pond area, and fish farming experience.

Table 3. Correlation between training need and other independent variables

S.No.	Variables	Correlation coefficient
1.	Age	-0.074
2.	Education	0.145
3.	Sex	0.104
4.	Family size	-0.115
5.	Pond area	-0.109*
6.	Occupation	0.999
7.	Annual income	0.076*
8.	Experience in fish farming	-0.043*
9.	Training undergone	-0.021
10	Source of information	0.257*
11.	Social participation	0.089
12.	Economic motivation	0.042
13.	Risk orientation	0.126
14.	Extension contacts	-0.057

(* Indicates significant at 5% level of significance)

DISCUSSION

Fisheries and aquaculture are important to a region's socioeconomic growth (Biswas et al., 2025). The high demand for aquaculture training aligns with previous studies emphasising the growing interest in scientific fish farming methods among farmers in the region. Farmers expressed a need for training in integrated and composite farming systems to enhance production and sustainability. Additionally, the dependency on fish seed imports has driven interest in hatchery management and nursery techniques, highlighting the necessity of establishing local hatcheries for better seed availability and reduced transportation costs (Debashis & Kumar, 2023). The findings indicate that disease prevention and control is a critical training priority, as fish farmers struggle with common diseases like epizootic ulcerative syndrome (EUS), leading to financial losses. Farmers require training in early disease detection, water quality management, and treatment protocols to minimise economic losses. The demand for training in water and soil quality management further highlights the challenge of acidic soil in the northeast region, which directly affects fish health and productivity. Mondal et al., (2025) reported that 78% of respondents exhibited medium to high training needs, with fish disease control and feeding strategies identified as key priority areas.

The high demand for hatchery management and fish seed production training reflects the state's dependency on fish seed imports. Fish seeds are primarily procured from Assam and other states, making their availability and cost a concern. Establishing local hatcheries not only improves seed availability but also reduces transportation costs and increases convenience for fish farmers. Hijam et al., (2015) reported that fish farmers have the highest training requirements in critical areas such as fish disease management, hatchery management, fish seed production, nursery management, and aquaculture. Training in pond construction and management is crucial, as many farmers lack scientific knowledge in farm planning and infrastructure development. Mondal et al., (2025) highlighted that knowledge of pond design and construction is essential for creating an optimal environment for fish growth. These skills can help farmers enhance fish stock quality and productivity. Additionally, the low preference for training on modern fishing equipment suggests that farmers continue to rely on indigenous fishing methods, which are cost-effective and locally accessible. This aligns with the observation that the construction and repair of indigenous fishing equipment ranked higher than modern fishing techniques in training needs. Training in fish processing and value addition is crucial for reducing dependency on imported fish products and promoting self-sufficiency among fish farmers. The strong demand for fish preservation, packaging, and drying techniques suggests potential for fisheries-based entrepreneurship and value chain development in Meghalaya. Since the majority of processed fish products, including fermented and dried fish, are imported from other states, farmers expressed an interest in training programmes that could help them develop their fish processing businesses.

The strong interest in social media-based training highlights the growing role of digital tools in fisheries extension. Social media platforms such as Facebook and WhatsApp serve as important tools for information sharing and business promotion (Awashreh & Bremananth, 2025). However, the low awareness of KVK portals and ICT initiatives suggests the need for targeted interventions to improve digital literacy among fish farmers. Improving access to mobile applications for fish farmers and e-Agriculture initiatives could enhance the dissemination of fisheries-related knowledge and best practices (Odunlade & Isikwei, 2025). Specific training priorities include the culture of economically important fish species, production of *Shidal* (fermented fish product) in fish processing, identification of causative factors for fish diseases, maintenance and operation of portable plastic carp hatcheries, and the design and construction of hatchery infrastructure. Fish farmers with higher annual incomes may have a significant advantage of starting up or expanding fish farming activities on a larger scale. So, they may seek more information, knowledge on innovative technologies, and other necessary inputs for their fish farming activities. Similarly, fish farmers having more access to different information may tend to develop more interest in fish farming, thereby seeking more training in fisheries activities. Arun Kumar et al., (2021) emphasised that poorly assessed training needs lead to inefficient resource use, with factors like motivation, job performance, self-attitude, and media exposure greatly impacting training effectiveness. Nain and Chandel (2010) emphasised that the variables like family

occupation, land holding, economic motivation, innovative proneness and information sources utilisation were positively and significantly associated with training needs of respondents.

The study emphasises the critical need for targeted training programmes in Meghalaya's fish farming sector. Future initiatives should focus on strengthening capacity in key areas such as aquaculture, fish disease management, hatchery operations, and value-added processing to promote sustainable and profitable fisheries and aquaculture in the region. The findings reinforce the need for location-specific training to address the unique challenges of the region and support the sustainable development of the fisheries sector. Well-designed training initiatives are essential to improving fish farming sustainability, profitability, and ultimately, the livelihoods of fish farmers in Meghalaya.

CONCLUSION

Fisheries and aquaculture in Meghalaya remain underutilised despite their immense growth potential demanded targeted capacity-building programmes are essential for fish farmers, enhancing productivity and income. Strengthening linkages among fisheries' stakeholders is vital for efficient knowledge transfer and resource utilization. Awareness programmes on key aspects like government schemes, financial support, diagnosing fish and pond health issues is crucial. The business skills of fish farmers could have also been included as a domain for training needs assessment in this study, as business skills are vital for profitability and sustainability in transforming the fisheries sector. Financial management, marketing, and supply chain efficiency help farmers maximise profit; expand opportunities, ensuring long-term success. The fish farmers in the study location were mostly smallholder traditional farmers with considerably low production level to scale up to the business level. Hence, only the aspects necessary to increase the fish production and productivity at the farmers' level were included.

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Research Article

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Value Chain Development of IARI Variety of Carrot: A Training Need Assessment

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HIGHLIGHTS

- The majority of the farmers (71.25%) perceived a medium to very high level of training need.
- The most sought-after training needs were using herbicides, vermicomposting, prevention of rotting, and contract negotiation skills.
- While mass media exposure and scientific orientation affected positively to training need, extension contact affected it negatively.

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Keywords: Value chain, *Pusa Rudhira*, Training need index, Farmers' income, Value chain integration.

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ABSTRACT

The green revolution made India self-sufficient in food production. Over the years, due to technological interventions, the quantity of food production increased to new heights. However, the income of farmers did not improve proportionately. Lack of integration of farmers to sustainable value chains could be one factor contributing to it. Under this impression, the research was conducted to identify the training needs of the farmers in the area of value chain development of the Carrot commercial variety (*cv.*) *Pusa Rudhira* during 2022. A total number of 80 farmers were selected randomly from Nizampur, Delhi, and Peer Nagar Sodhana, Uttar Pradesh. A training need index was developed. The findings showed that 71.25 per cent of the farmers had medium to very high need of training in the area of value chain development. The most sought-after training needs were the use of herbicides, vermicomposting, prevention of rotting, and contract negotiation skills. The identified areas may be given due consideration while organising training programmes for farmers so that they can upgrade themselves to better value chains and earn more income.

INTRODUCTION

According to the Food and Agricultural Organization (FAO, 2008), a 'value chain' in the farm sector consists of a set of actors and activities that facilitate a basic agricultural product from production to final consumption, where at each stage value addition is being done. Case studies in the Indian context have shown that farmers who participate in value chain incur less transaction cost, face minimum market risks and realise higher remuneration (Chengappa, 2018). Gupta (2015) reported that, in the Purnia district of Bihar, farmers associated with the maize value chain receive 11 per cent higher price than what the local aggregators offer. Ramappa et al., (2016) studied the value chain of tomatoes in Karnataka and found that the value chain approach has improved the marketing system, thereby benefiting the chain actors. The value chain approach promotes market-oriented agriculture while increasing smallholder farmers' income (Sanjeev et al., 2012)

However, the value chain sector is marred by several challenges. Farmers face challenges in access to regulated markets, unavailability of effective ICT solutions for agricultural value chain, and the absence of standardised regulations, making it challenging to analyse the micro-level aspects of the value chain (Hernandez al., 2017; Lahiri et al., 2024: Jana et al., 2025). Most of the small and marginal farmers do not have knowledge on production, storage and preservation of agricultural produce and how to constantly check

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quality. Their supply competencies are also poor. Moreover, the existence of middlemen, absence of data and information about other links, and not being able to invest in the value chain led to inefficiencies. By making the production, collection, storage, and delivery of the value chain efficient, the income of the smallholder farmers can be increased (Kumar et al., 2016). Singh et al., (2021) found that most of the carrot and okra growers need training in plant protection measures. Iduku (2019) have shown that women vegetable farmers require training in pest and disease management, fertiliser application, selecting appropriate fertiliser rates, and storage techniques.

Capacity building of the farmers can be one of the means to address these challenges (Kumar et al., 2024). Training is one of the important methods of capacity building. According to Sanjeev et al., (2012), it is a process of acquiring new skills, attitudes, and knowledge that facilitates entry into a profession or enhances productivity within an organisation or enterprise. Roy et al., (2021) found that there was significant improvement in the levels of knowledge, attitude and skill as a result of training. Jors et al., (2016) found that training farmers improved and performed in all the tested variables than their neighbouring farmers. The same study also reported that, the trained farmers improved the knowledge of their neighbouring farmers and their performance was better than the control group farmers. Similarly, Rasanjali et al., (2021) have reported that there is an impact of training on farmers' technological knowledge. The study provided evidence for continuance of agricultural training. The value chain approach is gaining traction in the agriculture sector due to its potential in enhancing farmers' income. Also, the farmers require training and capacity building to participate in better value chains. Though, several studies have been conducted to identify the training needs of farmers in the areas of crop production and management, studies in the area of value chain development are lacking.

METHODOLOGY

The study was conducted during February to April 2022. The sampling area consists of Uttar Pradesh and New Delhi. Farmers growing Carrot *cv. Pusa Rudhira* were the sampling units. From the state of Uttar Pradesh district Hapur and village Peer Nagar Soodhna was selected purposively. Similarly, from New Delhi, District Khanjawla and the village Nizampurwere selected purposively. The basis for purposive selection was that IARI had undertaken a project in these villages from 2011 to 2014 to enhance the cultivation of carrot *cv.* Pusa Rudhira (Singh et al., 2018). From each of the villages, forty farmers (40) growing Carrot *cv.* Pusa Rudhira were sampled randomly. So, the total number of farmers was eighty (80). The research design followed was ex-post facto in nature. Training was operationalised as the level of knowledge and skill requirement of the farmers in the area of value chain development. Value chain development was operationalised as an activity wherein all the stakeholders, starting from production to the final purchase of the produce, are linked in such a way that its maximum potential in terms of market efficiency, value addition, increasing income, and long-term viability can be realised. The training need was measured through the development of a training need index. The dimensions of the index i.e. crop production (CP), On-farm input production (IP), On-farm input production (IP), post-harvest management (PM) and farm business management (FBM) were finalised after an extant review of literature and discussion with experts. The validity of the dimensions and statements thereof were ascertained using content validity. The weightage of the dimensions was calculated using the AHP (Analytic hierarchy processes) method. After getting the weightage of the dimensions, the training need index score for each respondent was calculated as follows:

$$\text{Training Need Index} = \frac{CP*W1+IP*W2+PM*W3+FBM*W4}{W1+W2+W3+W4} * 100$$

Where, W1 = Weightage for crop production; W2 =Weightage for on-farm input production; W3 = Weightage for post-harvest management; W4 = Weightage for farm business management

The participants were classified into five groups ranging from very high training need to very low training need on the training need index score using the cumulative cube root frequency method. Pearson's correlation and multiple regression analysis were done by taking age, education, family size, occupational status, farming experience, operational holding, annual income, material possession, economic motivation, scientific orientation, social participation, cosmopoliteness, Mass media exposure, and extension contacts as independent variables and training index score as dependent variable. An interview schedule was prepared, and farmers growing Carrot *cv.* Pusa Rudhira were asked to give responses to their perceived training need. Their responses were recorded in a three-point continuum ranging from mostly needed to not needed.

RESULTS

Under the dimension of crop production, high training need was perceived under all the indicators except for the adjustment of sowing and harvesting time with the changing climate (1.43). According to the mean value, the top three areas were optimum use of weedicides (2.68), Soil health management (2.66) and optimum use of fertilisers (2.32). Similarly, under the dimension of on-farm input production, training need was high in Green manuring (2.10) and vermicompost production (2.02). Under post-harvest management, the majority of the farmers, i.e. 78 per cent, expressed that they needed training in preventing the rotting of the carrots in the field. The training need for post-harvest disease management was also high. Moreover, under farm business management, high training need was perceived in the areas of contract negotiation with processors (2.13) and the selection and maintenance of farm machinery (2.16). The responses of the farmers were used to calculate the overall training need index score, which showed that, for11.25 per cent of the respondents, the perceived training need was very low, while it was low for 17.5 per cent of the respondents. At the same time, 38.75 per cent of the respondents were in the medium level category, 18.75 per cent of the respondents fell in the high and 13.75 per cent in the very high category of training need. Thus, a large number of the participants had medium to very high levels of training need in the area of value chain development.

Table 2 shows that age has a significant and negative association with perceived training need as shown by the "r" value of -0.358. This may be because the respondents belonging to the young age

Table 1. Perceived training need of the farmers growing Carrot *cv.* Pusa Rudhira

Statements	Mostly needed (%)	Needed (%)	Not Needed (%)	Mean Value	Weightage of the dimension
Crop Production					2.87
Optimum use of fertilisers	37.50	57.50	5.00	2.32	
Integrated pest management	22.50	70.00	7.50	2.15	
Optimum use of weedicides	15.00	76.25	8.75	2.68	
Optimum use of plant protection chemicals	21.25	72.5	6.25	2.06	
Integrated disease management	16.25	71.25	8.75	2.07	
Soil health management	40.00	48.75	11.25	2.66	
Adjusting sowing and harvesting time with the changing climate	15.00	13.75	71.25	1.43	
On-Farm Input Production					3.65
Vermicompost production	13.75	75.00	11.25	2.02	
Green manuring	15.00	80.00	5.00	2.10	
Production of farm compost	15.00	50.00	35.00	1.80	
Quality seed production	11.25	15.00	73.75	1.40	
Post Harvest Management					4.67
Post-harvest disease management	21.25	73.75	5.00	2.16	
Storage of the produce	11.25	7.50	81.25	1.3	
Value addition and processing activities	20.00	26.25	53.75	1.58	
Preventing the rotting of the crop in the field	78.75	21.25	0.0	2.78	
Farm Business Management					4.25
Regarding taking farm loans and crop insurance	21.25	31.25	47.5	1.88	
Contract negotiation with processors/millers	12.5	63.75	23.75	2.13	
Regarding the formation of F.P.O	23.75	66.25	10.0	1.45	
Use of e-commerce facility to sell farm produce	11.25	22.5	66.25	1.73	
Regarding the selection of farm machinery and its maintenance	21.25	73.75	5.0	2.16	
Gathering of relevant information regarding farming and market	18.75	60.0	21.25	1.97	

Table 2. Correlation and regression analysis between independent variables and perceived training need

Model	Unstandardised Coefficients		Standardised Coefficients	T	p-value	Pearson Correlation	p-value
	B	Standard error	Beta			Coefficient	
Constant	0.675	0.123		6.601	0.000		
Age	-0.050	0.003	-0.187	-0.097	0.223	-0.358*	0.001
Education	-0.004	0.021	-0.098	-0.291	0.365	0.513*	0.016
Family size	0.000	0.007	-0.005	-0.329	0.441	0.010	0.010
Occupational status	-0.001	0.012	-0.021	-0.098	0.397	-0.119	0.293
Farming experience	-0.001	0.028	-0.007	-0.214	0.481	0.167	0.140
Operational holding	0.075	0.003	-0.005	-0.122	0.517	0.204	0.069
Annual income	-0.002	0.019	-0.001	-0.076	0.965	0.139	0.219
Material possession	-0.001	0.007	-0.010	-0.320	0.659	0.064	0.572
Economic motivation	0.004	0.009	0.070	0.029	0.392	0.198	0.324
Scientific orientation	0.001	0.005	0.020	2.513*	0.003	0.356*	0.003
Social participation	-0.008	0.021	-0.065	-0.074	0.320	-0.101	0.372
cosmopoliteness	0.002	0.012	-0.003	-0.291	0.197	-0.161	0.155
Mass media exposure	0.000	0.026	0.657	2.927**	0.001	0.374**	0.003
Extension contacts	0.000	0.013	-0.395	-3.139*	0.006	-0.418**	0.001

Level of significance 0.05(*) and 0.01(**) F ratio=10.790, R^2=0.811, Adjusted R^2=0.7704

category have more curiosity towards learning than older ones. Similarly, education has a positive and significant association with the training need needs of the respondents with an "r" value of 0.513. Furthermore, scientific orientation was positively and significantly related to training need. Similarly, mass media exposure was found to have a positive and significant association with the training needs of the farmers with an "r" value of 0.374. Similarly, extension contact had a negative and significant association with the training needs of the farmers.

Multiple regression analysis was done to find out the predictors of the perceived training need. To do this, a regression equation was fitted, keeping the training need index score as the

dependent variable with all other independent variables of the study. The training need index score was measured on a continuous, interval-level scale, making it suitable for parametric tests. The data shows that 77.04 per cent of the variance in the dependent variable can be attributed to the independent variables of the study, as shown by the "adjusted R^2" value of 0.7704. Three variables were found to be significantly contributing towards the perceived training need of the respondents. Scientific orientation (β=0.020) and mass media exposure (β=0.657) were found to positively affect the training need, and extension contact (β=-0.395) negatively affected the training need of the respondents.

DISCUSSION

Post-harvest management and farm business management got the highest weightage from the experts out of all four dimensions taken for the study. This may be because these components are very crucial for effective value chain development. In a study conducted by Kiran et al., (2010) on the post-harvest training needs of farm women in the Junagadh district of Gujarat, it was found that farm women desired training in areas such as selecting selling locations, pest control, timing of spraying, rodent control, storage pest management, seed bin information, threshing, and winnowing. Similarly, the significance of marketing has also been emphasised in various studies (Barman et al., 2013; Poonia, 2010; Kiran et al., 2016). Under the dimension of crop production, the training need was sought in the optimum use of weedicides and fertilisers and soil health management. In a study by Pandey et al., (2015) on the training needs of farmers regarding mustard production technology, it was reported that the majority lacked knowledge about plant protection measures and the application and use of manures and fertilisers. Similarly, Sajeev et al., (2021) studied the training needs of farmers and rural youth in the Nagaland district and reported that training is needed in soil fertility management. This may be because most of the farmers did not have access to immediate extension advisory in this regard. Similarly, under on-farm input production, farmers need training in vermicompost production and green manuring. Chhodavadia et al., (2018) reported that farmers mostly need training in the areas of getting subsidies and loans, control of disease and vermicomposting. When it comes to post-harvest management, most of the farmers needed training to deal with the prevention of rotting of the crop in the field. Rotting of carrot is a common problem faced by the farmers. Papparella et al., (2024) reported that faulty cultural practices can cause the rotting of carrots. Under the dimension of farm business management, farmers expressed their perceived training need for the selection of farm machinery and its maintenance and contract negotiation with processors. The overall training need was found to be very high in the area of value chain development. Age and extension contact were found to have a negative association with training need. Viva et al., (2005) also found that extension contact was negatively and significantly associated with the training needs of paddy growers. Additionally, education, scientific orientation, and exposure to mass media are positively and significantly correlated. This may be because farmers with high scientific orientation were more oriented towards applying the new farm technologies than farmers with low scientific orientation. The finding confirmed to Raghuvanshi (2014), who discovered that there was a significant relationship between farmers' scientific orientation and their training needs.

CONCLUSION

Given the importance of value chain in enhancing farmers' income, it is important to integrate them with a better and sustainable value chain. They must be equipped with the necessary skills and competencies. The current study found out their training need in the area of value chain development. The empirical findings show that majority of the farmers had medium to very high training needs. Training intervention should be carried out with a value chain orientation to improve the income and livelihood. Areas of training need that emerged in the study were; optimum use of herbicides, soil health management, green manuring, preventing rotting due to untimely rain, formation of farmers' organisations, contract negotiation skills, and purchase of farm machineries etc. These areas must be given due consideration by policymakers while designing effective value chain intervention programmes.

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Research Article

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Empowered by Enterprise: Evaluating Livelihood Status Improvement through Attracting and Retaining Youth in Agriculture (ARYA)

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HIGHLIGHTS

- The ARYA initiative has successfully engaged rural youth in agriculture for financial gain and fostered interest in agripreneurship.
- Participants have seen a significant improvement in their livelihood status index, with an overall mean score increase from 1.6 to 1.94, reflecting a 21 per cent improvement.
- The initiative has significantly contributed profitable enterprises and enhancing overall livelihood status.
- The ARYA initiative has driven sustainable livelihoods and income with minimal investment, creating a vibrant and resilient agricultural community among rural youth.

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ABSTRACT

The ARYA initiative by ICAR has effectively engaged rural youth in agriculture, promoting financial gain and interest in agripreneurship. ARYA project has transformed the agricultural landscape by retaining rural youth in the sector and empowering them with essential skills and opportunities. This study was conducted in Puri district of Odisha during 2024,aiming to assess farmers' livelihood status of ARYA entrepreneurs. A total 120 respondents were surveyed using structured interviews and secondary data sources. The results revealed that the overall mean score of livelihood status increased by 21 per cent, demonstrating the programme's success in ensuring sustainable livelihoods and income with minimal investments. Participants have shown significant improvements in their livelihood index, social participation, and information seeking behavior. This initiative has significantly contributed to the socio-economic development of rural areas, highlighting its role in driving sustainable change and fostering a resilient agricultural community. The positive outcomes of the ARYA initiative underscore its importance in promoting sustainable agricultural practices and enhancing the overall livelihood status of the rural youth.

INTRODUCTION

India's agricultural sector has experienced a significant transformation, evolving from a food-deficit nation to one with a food surplus over the past fifty years. This notable achievement is recognized globally and has ensured food security for multiple countries. The next stage in Indian's agricultural development relies heavily on encouraging entrepreneurship among the youth. Developing entrepreneurship within the agricultural sector is essential for introducing innovative solutions that can increase farm income, generate employment opportunities, and enhance rural prosperity. Awareness, motivation, technical skill, the right assistance from development department can strengthen the entrepreneurial capacities (Nain et al., 2013). Maximizing farm profitability is interplay of entrepreneurial competencies, entrepreneurial climate, and farmers' innovations which suggest

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convergence and synergistic linkages Nain et al., (2019). Kobba et al., (2021) established that the farm sector, four determinants of entrepreneurial success were family size, land size, turnover and annual income whereas in the non-farm sectors five determinants of entrepreneurial success were long term involvement, initiative, number of employees, entrepreneurial experience and annual income. However, a major challenge lies in attracting rural youth to agricultural entrepreneurship, as there is a prevalent belief that agriculture cannot meet their profitability expectations due to the large number of small and marginal farm families (Rana et al., 2004).

Given the importance of rural youth in agriculture, ICAR launched the "Attracting and Retaining Youth in Agriculture" (ARYA) programme on July 16, 2015. The initiative aims to draw rural youth towards agriculture and keep them engaged by involving them in agricultural enterprises, turning them into agri-entrepreneurs. The main goal is to install confidence in rural youth so they view farming as a viable career option, rather than pursuing menial job in urban areas (Sahoo et al., 2023). The ARYA programme has been designed to aid both existing rural enterprises and aspiring entrepreneurs by providing capacity-building opportunities and technological support (Gowda et al., 2023). The ARYA project offers vocational training across all aspects of agriculture and related sectors (Sharma & Sharma, 2021; Sayana et al., 2022). This scheme focuses on attracting rural youth under the age of 35 to agriculture by offering income-generating opportunities and actively engaging them in agricultural activities. Youth groups serve as role models by showcasing the potential of agri-based enterprises and providing training to others. Project aimed to attract and engage an increasing number of unemployed rural youth in farming-based enterprises (Kumar et al., 2022) and transform rural youth from job seekers into job creators (Nayak et al., 2024).

The ARYA programme, an innovative initiative by ICAR, has successfully attracted rural youth to agri-preneurship, ensuring their continued engagement in agriculture for profitable outcomes. Following the intervention of KVK, which promoted various agri-enterprises, rural youth were introduced to scientific methods in mushroom cultivation, beekeeping, poultry, and fish farming (Sahoo et al., 2023; Acharya et al., 2024). This exposure led to the adoption and establishment of these enterprises, aiding in income diversification and livelihood security, ultimately improving and sustaining their livelihood status.

METHODOLOGY

The current study was done in the state of Odisha. Five KVKs from Odisha namely, Cuttack, Nayagarh, Sambalpur, Ganjam and Puri carried out the ARYA programme in their respective districts. In present study, Puri and Nayagarh districts were chosen at random, where the ARYA programme has been conducted. In each district, a random sample of four enterprises were considered. The study has followed an exploratory sequential research design. The sampling procedure comprised of 15 respondents from each of the four enterprises i.e., Mushroom, Apiary, Fishery, & Poultry, thus a sample of 60 respondents from Puri district; and similarly, a sample of 60 respondents, 15 each from Mushroom, Backyard poultry, Fishery, and Nursery raising enterprises were selected. Therefore, a total of 120 respondents were selected following stratified random sampling method in the present investigation.

The dependent variable selected for the study was livelihood status of the respondents before and after undertaking entrepreneurial activities under ARYA programme. Schedule developed by Haobijam & Ghosh (2023) was used with modification to measure the level of livelihood of youth based on the five types of assets holding human assets, social assets, financial assets, physical assets and natural assets, each measured on a 5-ppoint continuum scale.The overall livelihood status of the rural youth enaged in various entrepreneurial activities was compared between pre-ARYA and post-ARYA period. Thereafter, the influencing factors of the rural youth's livelihood status was worked out separately for both pre and post ARYA period using correlation and multiple regression analysis.

RESULTS

Nayagarh is the first district of Odisha where ARYA programme was initiated (2015-16). A total of 100 youths from 82 villages were involved. Forty (40) youths were involved in nursery enterprise and 20 youths each for stunted fingerling production enterprise, backyard poultry rearing and mushroom enterprise, respectively, were involved. The ARYA was initiated at KVK, Puri in the year 2018-19. A total of 130 youths from 78 villages were involved in the project covering poultry, mushroom, fishery, and apiary enterprise. The enterprises included under ARYA have demonstrated significant profitability (100.66%). On an average, the annual expenditure of these enterprises amounted to Rs. 1,44,875, while the average annual income generated was Rs 2,90,708. This indicates that these ventures have yielded a commendable financial return, making them promising options for engaging rural youth with a sustainable income.

The study assessed the perceived level of five types of the livelihood assets that farmers require to support their livelihood before and after their engagement under ARYA programme in Nayagarh and Puri district. Following the involvement in entrepreneurship under the ARYA programme, a positive change is observed in the asset ownership and general well-being of farm youth's households (Table 1 and Figure 1). The overall mean score of physical assets increased from 3.71 to 4.00, while that of social, financial, and human assets increased from 2.97 to 3.35, 2.53 to 2.85, and 3.09 to 3.20, respectively. However, the position of natural assets remained poor with improvement from 1.60 to 1.94 on 5-point continuum.

Considering the overall assets holding of the respondents, the livelihood status of the respondents has increased by about 35 per cent after engaging in the entrepreneurship under the ARYA programme. Maximum improvement is witnessed by the entrepreneurs of nursery raising enterprise in Nayagarh district. While in Puri district, the most improved livelihood status is found in case of the poultry entrepreneurs (increased by about 10%). The factors influencing the differential level of livelihood status of the rural youth before and after their engagement in entrepreneurships under the ARYA programme were revealed through the correlational and multiple regression analyses. Prior to participating in ARYA, the farmers' overall livelihood status was significantly and

Table 1. Livelihood status of the respondents before and after undertaking entrepreneurial activities under ARYA programme

Livelihood asset	Mean (SD)															
	Enterprises in Nayagarh District								Enterprises in Puri District							
	Nursery		Mushroom		Fishery		Poultry		Fishery		Poultry		Mushroom		Apiary	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Physical Assets	3.51	3.91	3.65	4.01	3.5	3.8	3.86	4.06	3.81	4.11	3.89	4.00	3.65	4.11	3.79	3.94
Social assets	2.98	3.55	3.03	3.55	2.91	3.21	3.08	3.36	3.15	3.43	2.96	3.50	2.80	3.30	2.80	3.08
Financial assets	2.41	3.00	2.43	2.80	2.16	2.35	2.68	2.88	2.66	3.00	2.56	2.88	2.70	3.10	2.60	2.78
Human assets	2.63	3.05	2.65	3.01	2.73	3.03	3.51	3.63	3.23	3.36	3.13	3.36	3.46	3.43	3.18	3.2
Natural assets	1.58	1.74	1.64	2.09	1.69	2.06	2.01	2.48	1.90	2.00	1.76	2.10	1.48	1.54	1.25	1.41
Overall	13.11	15.25	13.40	15.46	12.99	14.45	15.14	16.41	14.75	15.90	14.30	15.84	14.09	15.48	13.62	14.41
Improvement (%)	16.32		15.37		11.24		8.39		7.80		10.77		9.87		5.80	

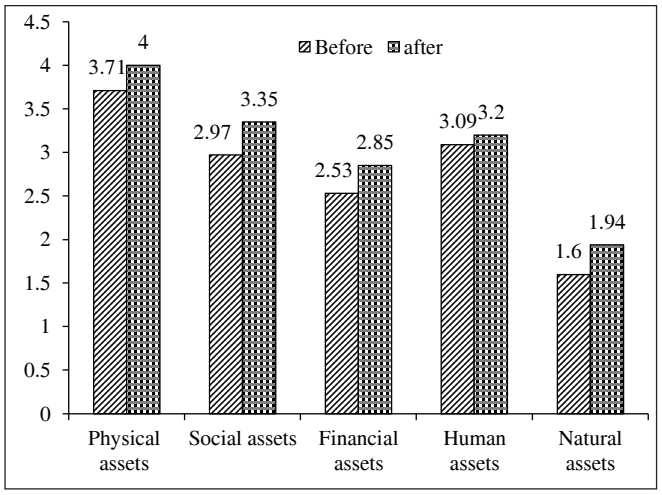

Figure 1. Livelihood status of the respondents before and after undertaking entrepreneurial activities under ARYA programme

positively correlated with their attributes like education, family size, number of earning members, average annual income from enterprise, land holding, average annual expenditure on enterprise, risk orientation, innovativeness, and decision-making power, as shown by the values of the coefficient of correlation in Table 2. These values explain that before the introduction of the ARYA programmes the young and educated farmers, who had strong risk orientation, innovativeness, and decision-making power, were involved in entrepreneurship as the beneficiaries of ARYA programme.

All the variables that demonstrated significant correlation with the overall livelihood status prior to participating in ARYA were also found to be significant with it after engaging in entrepreneurships under ARYA; additionally, the independent variables like information-seeking behaviour, and social participation are found positively significant, which indicates a substantial change brought by the implementation of the ARYA programme in terms of the information seeking behaviour and

Table 2. Correlation between attributes of the entrepreneurs and their overall livelihood status before & after engaging in entrepreneurship under ARYA programme

Independent variables	Coefficient of correlation (r) before engaging in ARYA	Coefficient of correlation (r) after engaging in ARYA
Age	0.103	0.035
Education	0.300**	0.313**
Family size	0.331**	0.311**
Number of earning members	0.326**	0.415**
Social participation	0.150	0.224*
Average annual income from enterprise	0.370**	0.332**
Land holding	0.578**	0.617**
Average annual expenditure on enterprise	0.385**	0.351**
Participation group/community activities	0.174	0.150
Information seeking behaviour	0.155	0.203*
Risk orientation	0.229*	0.278**
Innovativeness	0.225*	0.214*
Achievement motivation	-0.010	-0.013
Decision making power	0.246**	0.288**
Capacity building	0.134	0.148
Mass media exposure	0.101	0.083
Personal cosmopolite information sources used	0.054	-0.029
Personal localite information sources used	0.055	0.051
Number of Trainings received	0.044	-0.031

participation in various social organisations while indulging in the entrepreneurial activities under the ARYA programme. Multiple regression analysis between attributes of the rural youth and their overall livelihood status before and after engaging in entrepreneurships under ARYA programme was done to reveal the functional relationship between the attributes and overall livelihood status.The 19 independent variables together accounted for 48.50% of the variation in the overall livelihood status prior to participating in the ARYA programme, out of which, total farm land (p= 0.001), and education level (p= 0.025) was having significant functional relationship with overall livelihood status (Table 3).

Multiple regression analysis between attributes of the entrepreneurs and their overall livelihood status after engaging in entrepreneurships under ARYA programme reveals that the 19 attributes determine a 56.70 per cent variation in the overall livelihood status following participation in the ARYA programme (Table 4). While total farm land was found to be highly significant (p=0.000), the social participation (p=0.050), education level (p=0.018), and personal localite information sources use (p= 0.038) were found to have significant functional relationship with the overall livelihood status at the 5% level of significance. Therefore, to improve the farmers' prospects of living, these factors must be prioritized.

DISCUSSION

In the present investigation, five types of enterprises such as nursery, apiary, mushroom, poultry and fishery are studied from the perspective of entrepreneur engaged under ARYA programme in Puri and Nayagarh district of Odisha. The livelihood status of the engaged rural youth has improved by 10 per cent; the gain in social assets, financial assets and natural assets is found relatively more as compared to physical and human assets. Among the enterprises, the nursery enterprises have resulted an improvement of 16 per cent in livelihood status of entrepreneurs in Nayagarh district. Mushroom enterprise has resulted an improvement of 15 per cent and 10 per cent in livelihood status of entrepreneurs in Nayagarh and Puri district, respectively. An improvement of 7% in livelihood status is found in case of entrepreneurs engaged in fishery enterprise in Nayagarh and poultry enterprise in Puri district, respectively. Similar to the findings of present study few of the past studies also revealed the impact of ARYA programme, Sahoo et al., (2023) found the mushroom enterprise has best among other four enterprises with the highest net income and highest average production. However, they found highest benefit cost ratio in case fishery enterprise. Gowda et al., (2023) found nursery enterprises gained highest net income per unit. The nursery enterprise can produce earnings every day to the entrepreneurs. Production cycle is short for most of the fruits and vegetable seedlings and hence provides the opportunity for regular income generation. In the same study, it is reported that the fishery enterprise has the capability to generate employment for self as well as hired manpower in a commercial enterprise unit. Kumar et al., (2022) in their investigation on ARYA programme in the state of Bihar and Jharkhand stated that highest increase in net annual income was in apiary enterprise in Ranchi district of Jharkhand and lowest in Vaishali district of Bihar after training under ARYA

Table 3. Multiple regression analysis between attributes of the entrepreneurs and their overall livelihood status before engaging in entrepreneurships under ARYA programme

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	10.475	2.678		3.912	0.000
Age	0.033	0.031	0.094	1.077	0.284
Level of education	0.280	0.123	0.181	2.274	0.025
Family size	0.447	0.297	0.154	1.506	0.135
No. of earning members	0.179	0.224	0.086	0.800	0.425
Social participation	0.156	0.168	0.073	0.928	0.356
Average annual income from enterprise	2.040E-06	0.000	0.182	0.888	0.376
Total farm land	0.429	0.130	0.334	3.297	0.001
Average annual expenditure on enterprise (Rs)	8.221E-07	0.000	0.045	0.229	0.819
Participation in group/community activities	0.011	0.041	0.022	0.266	0.791
Information seeking behaviour	-0.019	0.060	-0.028	-0.322	0.748
Risk taking behaviour	0.069	0.055	0.104	1.249	0.215
Innovativeness	0.047	0.056	0.068	0.837	0.405
Achievement motivation	0.002	0.072	0.002	0.027	0.978
Decision making power	0.052	0.069	0.066	0.750	0.455
Capacity building	0.002	0.103	0.002	0.019	0.985
Mass media exposure	-0.002	0.016	-0.011	-0.112	0.911
Personal cosmopolite	0.078	0.112	0.070	0.693	0.490
Personal localite	-0.111	0.149	-0.078	-0.743	0.459
Number of Trainings received	-0.111	0.172	-0.067	-0.644	0.521
Model Summary					
Model	R	R Square		Std. Error of the Estimate	
1	.696[a]	0.485		1.429	

Table 4. Multiple regression analysis between attributes of the entrepreneurs and their overall livelihood status after engaging in entrepreneurships under ARYA programme

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	15.106	2.513		6.012	0.000
Age	0.008	0.029	0.022	0.279	0.781
Level of education	0.277	0.115	0.175	2.395	0.018
Family size	0.104	0.279	0.035	0.374	0.709
No. of earning members	0.388	0.210	0.182	1.845	0.068
Social participation	0.313	0.158	0.143	1.983	0.050
Average annual income from enterprise	2.237E-06	0.000	0.195	1.038	0.302
Total farm land	0.490	0.122	0.372	4.011	0.000
Average annual expenditure on enterprise (Rs)	6.302E-07	0.000	0.034	0.187	0.852
Participation in group/community activities	-0.004	0.039	-0.008	-0.108	0.915
Information seeking behaviour	-0.010	0.056	-0.014	-0.172	0.863
Risk taking behaviour	0.066	0.052	0.098	1.280	0.203
Innovativeness	0.028	0.052	0.040	0.536	0.593
Achievement motivation	-0.035	0.067	-0.039	-0.516	0.607
Decision making power	0.085	0.065	0.107	1.316	0.191
Capacity	0.060	0.097	0.069	0.622	0.536
Mass media exposure	0.002	0.015	0.014	0.165	0.869
Personal cosmopolite sources used	0.053	0.105	0.047	0.509	0.612
Personal localite sources used	-0.295	0.140	-0.203	-2.107	0.038
Number of Trainings received	-0.028	0.161	-0.016	-0.172	0.864
Model Summary					
Model	R	R Square		Std. Error of the Estimate	
1	.753[a]	0.567		1.341	

programme. In the present study, farmers' attributes like education, family size, number of earning members, average annual income from enterprise holding, average annual expenditure on enterprise, risk orientation, innovativeness and decision-making power are significantly and positively correlated with the overall livelihood status before practicing ARYA; additionally, another two attributes like social participation and information seeking behaviour are found significant after involvement in ARYA programme. Various economic performance indicators showed a positive and significant relation with the social profile of rural youth (Sahoo et al., 2023). Thus, present findings reiterate that ARYA programme seeks to attract youth in agriculture, enhancing their overall livelihood status (ICAR, 2019; Murthy et al., 2019). Engaging rural youths in profitable agricultural enterprises can ensure sustainable livelihood and income with minimal investment while improving their overall livelihood status (Som et al., 2018; Sahoo et al., 2023).

CONCLUSION

ICAR's ARYA initiative has notably succeeded in keeping rural youths engaged in agriculture for financial gain and fostering an interest in agri-preneurship. The initiative's impact is underscored by the increase in the overall mean score of livelihood status from 1.6 to 1.94, reflecting a 21 per cent improvement. The ARYA project stands out as a pivotal effort to transform the agricultural landscape but not only retaining rural youth in the sector but also empowering them with the necessary skills and opportunities to thrive. By ensuring profitable enterprises and enhancing overall livelihood status, the initiative has contributed significantly to the socio-economic development of rural areas. The positive outcomes of the ARYA initiative highlight its role in driving sustainable change and fostering a vibrant and resilient agricultural community among the rural youth. Overall, the initiative has to be a cornerstone in the pursuit of sustainable agricultural practices and the upliftment of rural livelihoods.

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Research Article

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Understanding Entrepreneurial Behaviour of Makhana Growers in Bihar Using SEM-PLS Approach

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HIGHLIGHTS

- Considerable difference in entrepreneurial behaviour levels was observed among makhana growers across different districts.
- Achievement, Production, and Risk-taking were the most significant contributors towards entrepreneurial behavior. Innovativeness and Marketing were the weak influencers.
- Economic factors (Land, Annual Income, Income from Makhana) strongly influenced entrepreneurial traits, with loading factors exceeding 0.89.

ARTICLE INFO

Keywords: Makhana, Entrepreneurial behaviour, Factors, Income, SEM-PLS.

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ABSTRACT

The study aimed to identify the factors that influence the entrepreneurial behaviour of Makhana growers. During 2022-24, data were collected from 120 Makhana growers across four leading districts (Purnea, Darbhanga, Katihar, and Madhubani) in Bihar using a structured schedule. Various socio-economic and entrepreneurial characteristics of the farmers were analyzed using Structural Equation Modeling (SEM) with Partial Least Squares (PLS). The findings revealed that more than three-fifths (67.50%) of makhana growers possessed medium entrepreneurial behavior followed by 19.16 per cent of them with low level of entrepreneurial behaviour and only 13.33 per cent of them exhibited high level of entrepreneurial behaviour. The findings indicated that variables Achievement, Production, and Risk were strong indicators of entrepreneurial behaviour. Makhana farmers always dare to take risks and persistent and disciplined to undertake cultivation activities. Additionally, knowledge and skills need to be constantly updated to enhance the ability to innovate and be creative in carrying makhana cultivation activities successfully.

INTRODUCTION

The management of agricultural practices has become a significant concern, particularly in developing countries like India, where farmers face numerous challenges in achieving sustainable agricultural productivity. This issue is particularly acute in Bihar, where Makhana (fox nut) cultivation plays a vital role in the local economy. Despite its importance, the farming community still faces several challenges in adopting innovative and entrepreneurial practices, which can impact both productivity and economic outcomes. Bihar is the main producer of Makhana in the country producing more than 80 per cent of the country's total production (Kumar et al., 2020). According to the ICAR National Research Centre for Makhana Research in Darbhanga, the total area under Makhana cultivation in India is around 15,000 hectares, with an average production of 1.5 t ha^{-1}. The total output of Makhana seeds is around 1,20,000 MT, which becomes 40,000 MT of Makhana pop after processing. Makhana production is projected to be worth Rs. 250 crores at the farmer level, however, it earns Rs. 550 crores at the trader's level (Sonu & Jha, 2025). In Bihar, the area under Makhana cultivation is about 13,000 hectares, contributing to 85% of India's total production. Darbhanga and Madhubani districts alone account for approximately 80 per cent of the processed Makhana production (Ahmad, 2020).

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A substantial amount of agricultural production in Bihar is lost due to inadequate management practices, pests, and market limitations which has a detrimental effect on farmer livelihoods. The reliance on conventional methods is not sufficient to meet the growing demands for Makhana in both local and international markets. In light of these challenges, it is crucial to identify innovative methods that could help farmers increase production while ensuring environmental sustainability. Integrated approaches to farming, including entrepreneurial strategies and market-driven innovations, are crucial for improving agricultural outcomes. Thusa comprehensive understanding of the socio-economic, demographic, and psychological factors influencing entrepreneurial behaviour of Makhana growers is essential. Entrepreneurial behaviour can be described as the process of recognizing potential opportunities and effectively implementing innovative ideas (Wang et al., 2022). Promoting entrepreneurship can improve socio-economic development (Vukovic et al., 2017).

The objective of this study was to determine the key factors influencing the entrepreneurial behaviour of Makhana growers in Bihar using SEM-PLS approach. The study aimed to identify how socio-economic factors such as age, annual income, makhana income, land, and knowledge of Makhana cultivation influence the entrepreneurial decisions of Makhana growers. Given the complex nature of agricultural entrepreneurship, various factors–ranging from access to information and resources to cultural and environmental factors–play an essential role in shaping entrepreneurial intentions and behaviour.

By applying SEM-PLS approach, this study made an endeavour to identify the factors significantly affecting the likelihood of Makhana growers exhibiting entrepreneurial behaviour that can enhance productivity and sustainability. The results will provide insights into how policymakers, agricultural extension services, and development agencies can promote entrepreneurial practices among Makhana growers, ultimately contributing to more sustainable agricultural practices and improved economic outcomes in Bihar.

METHODOLOGY

This research was conducted in Bihar, focusing on makhana farmers from the districts of Purnea, Katihar, Darbhanga, and Madhubani during 2022–24. Primary data were collected through observations, interviews, and discussions using structured interview schedule to gather insights into farmers' characteristics, including independent variables and entrepreneurial traits. The research employed a survey method, with a simple random sampling approach involving 120 farmers. Collected data were processed and analyzed using R-Studio. SEM was chosen for its ability to represent relationships between constructs within a direct model (Wijanto, 2008). Data analysis in R Studio examined two variables: endogenous latent variables (entrepreneurial characteristics) and exogenous latent variables observed through variable indicators.

The data analysis included two key stages: Outer Model Analysis and Inner Model Analysis. The Outer Model evaluates the relationships between indicator (manifest) and latent variables by assessing the Loading Factor (λ), where a value above 0.5 indicates validity. The Inner Model assesses relationships between latent variables.

The data analysis included two key stages: Outer Model Analysis and Inner Model Analysis. The Outer Model evaluates the relationships between indicator (manifest) and latent variables by assessing the Loading Factor (λ), where a value above 0.5 indicates validity. The Inner Model assesses relationships between latent variables. Mathematically, the structural equations for this study are represented as follows:

1. Structural Equation Modeling

$$\eta 1 = \lambda 1\, X1 + \gamma 2\, X2 + \gamma 3\, X3 + \gamma 4\, X4 + \gamma 5\, X5 + \gamma 6\, X6 + \zeta 1$$

2. The Measurement Model of Endogenous Latent Variables

$$Y1 = \lambda 1\, \eta 1 + \varepsilon 1$$
$$Y2 = \lambda 2\, \eta 1 + \varepsilon 2$$
$$Y3 = \lambda 3\, \eta 1 + \varepsilon 3$$
$$Y4 = \lambda 4\, \eta 1 + \varepsilon 4$$
$$Y5 = \lambda 5\, \eta 1 + \varepsilon 5$$
$$Y6 = \lambda 6\, \eta 1 + \varepsilon 5$$

3. The Measurement Model of Exogenous Latent Variables is as follows:

$$X1 = \lambda 7\, \zeta 1 + \delta 1$$
$$X2 = \lambda 8\, \zeta 2 + \delta 2$$
$$X3 = \lambda 9\, \zeta 3 + \delta 3$$
$$X4 = \lambda 10\, \zeta 4 + \delta 4$$
$$X5 = \lambda 11\, \zeta 5 + \delta 5$$

η1= endogenous latent variable of entrepreneurial Characteristics, γ= regression coefficient of the structural equation model, ζ= error component model, Y1-Y6= endogenous latent variable of entrepreneurial behaviour, X1-X5= exogenous latent variable of independent variables, λ= loading factor of indicator variable in exogenous and endogenous latent, δ, ε= error in the regression model of the indicator variable

RESULTS

It could be inferred from Table 1 that approximately two-thirds (65.83%) of the makhana growers had exhibited a medium level of innovativeness, while a similar proportion (60.00%) had demonstrated a medium level of risk-taking ability. In the study area, most makhana growers had been middle-aged, had completed education up to high school, had been small-scale farmers, and had had moderate exposure to mass media but limited contact with extension services. These factors might have constrained their ability to adopt new practices on their land, ultimately contributing to their moderate level of innovativeness. More than half (56.66%) of the makhana growers had possessed a medium level of production, while the majority (70.83%) had exhibited a medium level of achievement. Many makhana growers had likely excelled in attracting customers to their farming through various strategies. Over time, they might have utilized their experiences and effective communication skills to engage customers effectively. In contrast, makhana growers with low management might have adopted a more mechanical approach to their farm operations. When a makhana grower had been driven by enthusiasm and determination, it had boosted their self-confidence, ultimately contributing to the success of their farming and improving their economic stability. It was evident that over three-fifths (67.50%) of the makhana growers had exhibited a medium level of entrepreneurial behaviour. This distribution

Table 1. Distribution of makhana growers according to different components of entrepreneurial behaviour

Component of Entrepreneurial Behaviour	Category			Mean Score	S.D.
	Low (%)	Medium (%)	High (%)		
Innovativeness	17.50	65.83	16.67	21.19	2.45
Achievement	09.17	70.83	20.00	17.80	185
Risk-taking	20 .00	60.00	20.00	17.84	1.84
Management	19.17	68.33	12.50	22.19	2.01
Production	21.67	56.66	21.6 0	18.86	1.90
Marketing	19.17	68.33	12.50	22.17	2.01
Overall entrepreneurial behaviour	19.17	67.50	13.33	120.07	7.83

indicated that the majority of makhana growers displayed moderate entrepreneurial traits, with smaller proportions having shown either high or low levels of such behaviour.

Measurement model evaluation

The first step in assessing the measurement model using SEM-PLS was to evaluate the loading factor. This value served as a key indicator to determine the model's accuracy. If an indicator variable had possessed a loading factor (λ) below 0.4, it had been considered unsuitable for analysis and had to be excluded, necessitating a model verification illustrated in Figure 1.

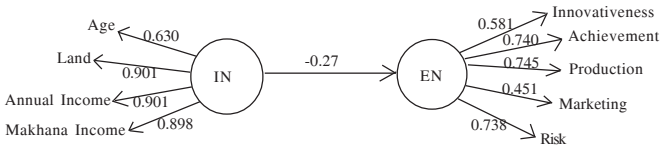

Figure 1. Cross Diagram Model on Factors (IN) Influencing the Entrepreneurial Behaviour (EN)

Table 2 revealed that the Independent Variable (IN) latent construct had been defined by its manifest variables: Age, Land, Annual Income, and Makhana Income. The loading factors and t-values for these indicators demonstrated their strength and statistical significance in contributing to the measurement of the latent construct. Specifically, Land, Annual Income, and Makhana Income exhibited very strong loading factors of 0.901, 0.901, and 0.898, respectively, indicating that these variables had been critical in defining the Independent Variable (IN) construct. The corresponding t-values for these indicators had been 6.88, 6.98, and 6.91, respectively, all of which had been highly statistically significant ($p < 0.001$). In addition to these strong indicators, age also contributed to the Independent Variable (IN) construct, albeit with a slightly lower loading factor of 0.630. Despite this moderate strength, the t-value of 4.85 ($p < 0.001$) had indicated that the relationship between Age and the latent construct had been statistically significant. This suggested that Age had been a meaningful indicator, though its contribution had been less pronounced compared to Land, Annual Income, and Makhana Income. The high loading factors and significant t-values for Land, Annual Income, and Makhana Income highlighted the economic and resource-based dimensions of the Independent Variable (IN) construct.

Table 2. Contribution of Independent Variable based on Loading Factor and T-Value

Latent Variable	Manifest Variable	Loading Factor	T-Value
Independent Variable	Age	0.630	4.85
	Land	0.901	6.88
	Annual Income	0.901	6.98
	Makhana Income	0.898	6.91

Table 3 presented the loading factors and t-values for the manifest variables associated with the Entrepreneurship Characteristics latent construct. These results were derived from a Partial Least Squares Path Modeling (PLS-PM) analysis, which evaluated the strength and significance of the relationships between the latent construct and its indicators. The Innovativeness variable had a loading factor of 0.581, indicating a moderate contribution to the Entrepreneurship Characteristics construct. However, its t-value of 1.23 suggested that the relationship was not significant ($p > 0.05$). Similarly, Marketing had a loading factor of 0.451, which was relatively low, and its t-value of 1.04 was also non-significant. In contrast, Achievement, Production, and Risk variables exhibited stronger loading factors of 0.740, 0.745, and 0.738, respectively. These values suggest that these variables are meaningful indicators of Entrepreneurship Characteristics. Their t-values of 2.82, 2.88, and 2.87, respectively, were all statistically significant ($p < 0.05$). Table 4 showed that the path coefficient for IN -> EN is -0.27, indicating a negative relationship between the two constructs. That means that as the Independent Variable (IN) values increases, the Entrepreneurship Characteristics (EN) values tend to decrease. The t-value for this relationship was -3.04, which was found significant ($p < 0.05$).

DISCUSSION

A significant proportion of makhana growers exhibited a medium level of innovativeness and risk-taking ability. Singh and Kumar (2019) found that farmers with moderate exposure to

Table 3. Contribution of Entrepreneurial Characteristics based on Loading Factor and T-Value

Latent Variable	Manifest Variable	Loading Factor	T-Value
Entrepreneurship Characteristics	Innovativeness	0.581	1.23
	Achievement	0.740	2.82
	Production	0.745	2.88
	Marketing	0.451	1.04
	Risk	0.738	2.87

Table 4. Path Coefficient Value

Relationship	Original Sample Value	T-value	Significance
IN -> EN	-0.27	-3.04	Significant

education and mass media tended to exhibit medium levels of innovativeness due to limited access to advanced resources and extension services. Similarly, Meena et al., (2020) highlighted that middle-aged farmer with moderate educational backgrounds often demonstrated a balanced approach to adopting new practices. Moderate level of production and achievement motivation of makhana growers may be attributed to their small-scale farming operations and limited access to extension services. These findings resonated with the work of Patel & Desai (2018), who emphasized that small-scale farmers in India often faced constraints such as limited financial resources, lack of technical knowledge, and inadequate institutional support, which hindered their ability to achieve higher levels of productivity and motivation. However, the ability of makhana growers to attract customers through effective communication and experiential strategies reflected their entrepreneurial characteristics, as noted by Sharma & Gupta (2021) in their study. The role of enthusiasm and determination in boosting self-confidence and economic stability among makhana growers was consistent with the findings of Reddy & Rao (2017). They argued that intrinsic motivation and a positive attitude toward farming significantly contributed to the success of agricultural enterprises. This was particularly relevant in the context of makhana cultivation, where growers relied on their passion and resilience to overcome challenges and improve their livelihoods. The mechanical approach adopted by growers with low management skills underscored the importance of capacity-building interventions. As suggested by Joshi & Tiwari (2016), training programs and access to extension services could empower farmers to adopt more efficient and innovative farming practices, thereby enhancing their productivity and economic outcomes.

The majority of makhana growers possessed moderate level of entrepreneurial behaviour, might have been influenced by various socio-economic and institutional factors. These findings aligned with the work of Kumar and Singh (2020), who found that a majority of small-scale agri-entrepreneurs in India exhibited moderate entrepreneurial behaviour due to limited access to resources, training, and market linkages. Similarly, Mehta & Choudhary (2019) observed that moderate levels of entrepreneurial behaviour were common among farmers and nursery owners operating in resource-constrained environments including factors like limited access to formal education and training in entrepreneurship, which restricted their ability to develop advanced business skills. Sharma & Gupta (2021) highlighted that many small-scale entrepreneurs in rural India lacked exposure to modern business practices, limiting their capacity to innovate and take risks. Findings also align with Kobba et al., (2021) & Gupta et al., (2023). The absence of robust institutional support, such as access to credit, technical guidance, and market information, may have hindered their ability to scale up their operations and adopt entrepreneurial strategies, as emphasized by Patel & Desai (2018) & Kademini et al., (2024).

The findings of strong loading factors for Land, Annual Income, and Makhana Income, along with their high statistical significance, indicated that these variables were crucial determinants in the entrepreneurial behaviour of makhana growers. This aligned with several studies conducted on climate-smart agriculture technologies (CSAT) adoption in India, which found that annual income was significantly correlated with farmers' awareness and adoption of CSAT (Mallappa & Pathak, 2023). Similarly, research on organic farming adoption in Haryana, India, identified economic factors as one of the six critical determinants driving 71.0 per cent variations in organic farming adoption (Kumar et al., 2023). The moderate but statistically significant loading factor for Age suggested that while it played a role in entrepreneurial decisions, its influence may have been less pronounced compared to land ownership and income. This was consistent with findings from a study in Northern Bangladesh, where age was not identified as a significant factor in the adoption of improved farm practices (Farid et al., 2016).

The PLS-PM analysis revealed varying contributions of different factors to the Entrepreneur construct. Achievement, Production, and Risk demonstrated strong and statistically significant relationships with the Entrepreneur construct, as evidenced by their high loading factors (0.740, 0.745, and 0.738 respectively) and t-values exceeding 2.5 (Alshebami & Seraj, 2022). These findings aligned with previous research highlighting the importance of need for achievement, production capabilities, and risk-taking propensity in entrepreneurial behaviour (Alshebami & Seraj, 2022; Mahmood et al., 2019). Interestingly, Innovativeness and Marketing showed weaker associations with the Entrepreneur construct. The moderate loading factor (0.581) and non-significant t-value (1.23) for Innovativeness contradicted some earlier studies that emphasized its crucial role in entrepreneurship (Jaziri & Miralam, 2023; Valaei et al., 2017). Similarly, Marketing's low loading factor (0.451) and non-significant t-value (1.04) suggested a less prominent role in this context. These findings diverged from expectations, as innovation and marketing were often considered vital for entrepreneurial success (Mukhtar et al., 2023; Valaei et al., 2017).

The observed negative path coefficient ($\hat{a} = -0.27$, $p < 0.05$) between the independent variable (IN) and entrepreneurial characteristics (EN) suggested an inverse relationship, where higher values of IN (e.g., socio-economic factors such as age, landholding size, or traditional income reliance) correlated with lower entrepreneurial traits. This finding aligned with studies in Indian agricultural contexts, where structural and socio-economic constraints often dampened entrepreneurial behaviour. For instance, Singh & Agarwal (2018) noted that farmers with larger landholdings in Bihar exhibited risk-averse tendencies, preferring conventional practices over innovative ventures due to perceived stability. The statistical significance ($t = -3.04$) reinforced the robustness of this relationship, suggesting that entrenched socioeconomic factors like age, lack of formal education, or limited exposure to extension services may have hindered entrepreneurial mindsets. Sharma et al., (2019) corroborated this, where older farmers with low education levels demonstrated reluctance to adopt new technologies or marketing strategies, resulting in stagnant business growth. This reflected the "resource curse" paradox, where existing assets (land, stable income) reduced the urgency to innovate, as noted by Patel and Desai (2021) in their analysis of Gujarat's agricultural communities. To mitigate this, targeted interventions such as entrepreneurial training, access to microfinance, and exposure to modern agri-business models were critical. As Joshi & Roy (2022) emphasized, bridging knowledge gaps through farmer-producer organizations (FPOs) could empower smallholders to transcend traditional practices and embrace entrepreneurial opportunities.

CONCLUSION

The study highlights that makhana growers predominantly exhibit moderate innovativeness and entrepreneurial behaviour, influenced by socio-economic constraints such as limited access to resources and education. SEM-PLS had shown that production and risk-taking ability were the most impacting components on the entrepreneurial behaviour of makhana growers, yet most of the makhana growers had medium innovativeness and marketing. Hence, there is a need to conduct intensive training programmes to expose the makhana to entrepreneurial opportunities, decision-making, innovations, time and financial management skills.

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Research Article

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Effect of Digital Devices and Parental Regulations on Adolescents' Achievement Motivation: A Quantitative Study

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HIGHLIGHTS

- Exposure to digital gadgets have significant impact on the achievement motivation
- Parental rules set by the family at home for mindful usage of screens, also influence achievement motivation
- No gender difference was found in the achievement motivation and use of digital devices among participants

ARTICLE INFO

Keywords: Digital, Screen-time, Achievement-motivation, Gadgets, Exposure.

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ABSTRACT

The increasing reliance on digital devices presents both benefits and challenges, particularly during adolescent years. The present study was conducted from January to December 2024. A sample of 300 adolescents aged 14-16 years was selected. Quantitative research design, self-structured close-ended questionnaires were administered through surveys. The study aimed to investigate the impact of digital devices and parental rules on the achievement motivation of adolescents. Participants reported that the use of digital devices for educational purposes and the time spent on these devices for school assignments significantly influenced their motivation. The findings indicated that distractions and lack of concentration in the classroom, attributed to digital devices, adversely affected the participants' achievement motivation. Results also demonstrated that digital devices offer opportunities for personality development, which in turn influences achievement motivation. Parental regulations on screen time played a crucial role in shaping adolescent motivation, emphasising the importance of structured digital habits. The findings can assist teachers, educational institutions, policymakers, and counsellors in promoting mindful digital habits. Encouraging balanced screen exposure and reinforcing achievement motivation can contribute to healthier academic and psychological development among adolescents.

INTRODUCTION

The widespread adoption of digital devices has significantly transformed the landscape of adolescent development and education in recent years. COVID-19 pandemic necessitated intrusion of technologies in both teaching and learning methods that provide opportunities to both students and instructor to achieve their targeted millstones. College students had positive perception towards e-learning (Singh et al., 2024). If new education policy 2020 is applied with its set objectives, it can help children to develop creative and abstract thinking that will be crucial in the achievement of their goals. Pandey et al., (2020) explored social media usage among college students and highlights rampant usage of social media in which WhatsApp and Facebook are the most used social platforms. Students spent significant amount of time on these platforms and perceived various health issues due to engagement in irrelevant activities on digital devices. Research indicates that adolescents with higher digital skills tend to take more online opportunities, which can potentially enhance their achievement motivation (Rodríguez-De-Dios et al., 2018). However, these digitally skilled adolescents also experience more online risks, highlighting the need for balanced digital engagement.

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Parental involvement plays a crucial role in shaping adolescents' digital habits and academic attitudes. These rules can range from setting time limits and content restrictions to monitoring online activities and promoting a balance between screen time and other activities. Parental mediation plays a crucial role in this context, with restrictive mediation negatively affecting online opportunities and risks through digital literacy (Rodríguez-De-Dios et al., 2018). Interestingly, parental involvement and monitoring strategies have shown mixed results in influencing adolescent behavior and achievement motivation. While parental knowledge and family rules about dating were found to decrease the likelihood of early sexual initiation (Ethier et al., 2016), excessive parental control can have negative effects on adolescents' autonomous motivation and achievement (Lowe & Dotterer, 2013; Suizzo et al., 2015). The study on parent-adolescent career congruence demonstrates that alignment with parents' wishes positively affects academic motivation and work hope (Fantinelli et al., 2023). The impact of digital devices and parental rules on adolescents' achievement motivation is complex and multifaceted. Strategies that enhance parent-child relationships, such as open communication and mutual understanding, are more likely to positively influence adolescents' achievement motivation in the digital age (Lowe & Dotterer, 2013; Suizzo et al., 2015)

Motivation is crucial for survival of a human being and that affect behavior of a person. Motivation affects an individual's whole performance besides perception and learning capabilities in a nurturing atmosphere. Human beings strive on some needs and want which needs to be satisfied. It encompasses various aspects such as intrinsic and extrinsic motivation, self-efficacy, and goal orientation.

This research paper seeks to explore the intricate interplay between digital device usage, parental rules, and achievement motivation in adolescents. By examining these relationships, the researcher aims to contribute valuable insights to the ongoing discourse on technology's role in education and provide evidence-based recommendations for parents, educators, and policymakers to foster positive academic outcomes in the digital era.

METHODOLOGY

For the present study Rewari district 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 where schools were selected again by the chit system to ensure an unbiased selection process.

Adolescents in the age group of 14-16 years were approached from the schools. Prior permission was taken from the Principals of schools and students who expressed willingness to participate were included in the study, ensuring voluntary participation. Informed consent was obtained from the respondents and their guardians. The study adhered to ethical research guidelines, ensuring the anonymity and confidentiality of participants. Ethical approval was also granted by the department ethical committee with its Ethics Committee number H.Sc./EC/027/24.02.2023.

Data was collected using both self-made and standardized tools. Participants were directly contacted in their respective schools as part of the data collection process. The academic achievement motivation test (revised version) (AAMT-ST) by Sharma, 2014) was used to assess the achievement motivation of the respondents. It contains 38 statements each statement with two response situations A & B. The respondents had to select either A or B situation as a response based on their thinking. The correct answer shows the situation of motivation. The total scores received by the respondent's measure the level of academic achievement motivation.

To evaluate the digital gadget usage and parental regulation, a self-structured, close-ended questionnaire was developed. The tool was used to assess the extent of digital gadget usage among adolescents and parental regulations regarding their usage. The reliability of this tool was tested using Cronbach's alpha formula, yielding a score of 0.8, which is considered excellent for internal consistency. The items covered dimensions such as: Where/physical-space, When/timings, What /type of content and How much/duration to watch and adult Supervision during screen time. Participants were given clear instructions as to how to fill the items and doubts if any were clarified before they proceeded. Approximately, half an hour was given to each participant to complete the survey. The results of the study were interpreted using Statistical Packages for Social Sciences (SPSS 16.0).

RESULTS

The results in Table 1 depicts that not a single participant either girl or boy scored extremely high on academic achievement motivation scale. It shows that 6 percent girls and 4.7 percent boys had high academic achievement motivation level. Two percent girls and twelve percent boys had above average level of achievement motivation. Out of total respondents, 24.7 percent girls and 30.7 boys were average. About 17.3 percent girls and 18.7 percent boys came into the category of below average. Girls and boys accounted as 16.7 percent and 15.3 respectively were scored low. Lastly, 15.3 girls and 18.7 percent of boys were extremely low level of motivation regarding their academic achievement.

Figure 1 displays the distribution of Z- scores ranging from -2 & below to +2 to above. It indicates that more than half of the scores obtained by the adolescents lie between -0.50 to +0.50 followed by -1.25 to +1.25, -1.26 to +1.26 and -2.01 to +2.01. a smaller number scores are concentrated at the extreme ends of the Z-score range. Overall, the graph suggests the normal distribution.

Table 1. Level of Achievement Motivation among Adolescents

Category	Girls (n=150) (%)	Boys (n=150) (%)
Extremely high	Nil	Nil
High	6.0	4.7
Above average	2.0	12.0
Average	24.7	30.7
Below average	17.3	18.7
Low	16.7	15.3
Extremely low	15.3	18.7

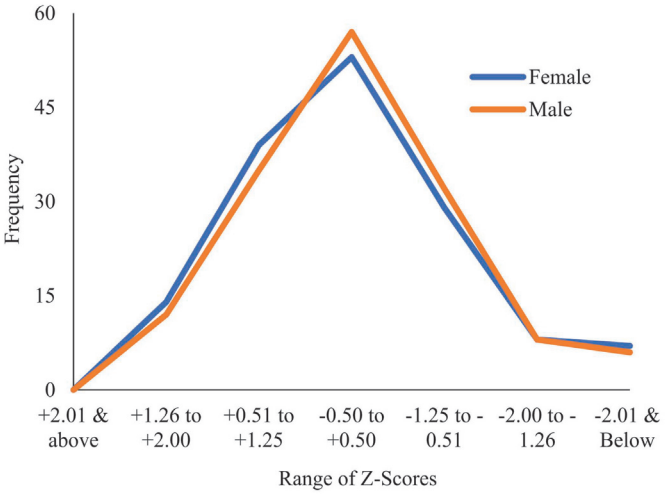

Figure 1. Z-Scores of achievement motivation among adolescents

Table 2 shows the differences in the use of digital gadgets in academics among girls and boys. It highlights that there was significant difference as per gender of the respondents, regarding amount of time adolescents spend on digital devices to complete their school assignments ($F=20.701$, $p<0.01$), lack of concentration in classroom due to prolonged exposure to screens ($F= 5.129$, $p<0.01$) and time spent on devices for entertainment ($F=0.325$, $p<0.05$). The other variables including, digital gadgets cause distractions in academic activities ($F=0.05$, $p>0.05$), use of these devices for educational purposes ($F= 0.498$, $p>0.05$) digital gadgets provides opportunities to improve personality ($F= 0.261$, $p>0.05$) and encouraged by other's success stories expressed a slight or negligible differences among girls and boys.

Table 3 explains the parental regulations regarding digital devices usage at home. The results found that 42.67 girls and 44.67 boys had rules at home regarding when to watch screen, whereas 57.33 girls and 55.33 boys reported that they do not have rule about when to watch screens. Findings revealed that 26.67 girls and 42.00 boys said that their parents set rules regarding where to watch screen. Seventy three percent girls and 58 percent boys reported they do not have any rules regarding where to watch screens. The outcomes of the study demonstrated that 47.33 percent girls and 66 percent boys had rules about what to watch on screens while 52.67 percent girls and 34 percent boys accepted that their parents did not set regulations for the type of content exposed on screens. It showed that 44 percent girls and 38.67 percent boys had rules like how much time spent on digital devices, 28.67 girls and 41.33 percent boys reported that their parents sometimes set rules about how much time to watch on screens and remaining 27.33 percent girls and 20 percent boys said their parents do not set time limits for screen usage. When the respondents were asked about how often they follow these rules then half of them reported that they always follow rules and regulations regarding screen usage set by their parents at home whereas 27.33 percent girls and 29.33 percent boys rarely follow these rules. The respondents who do not follow these rules were 16.67 percent girls and 20.67 boys respectively. The above table highlights that 34.67 percent girls and boys were allowed to watch digital devices under the supervision of adults, 31 percent girls and 38 percent boys reported that they are sometimes allowed to watch screens only under adult supervision. It indicated that 34 percent girls and 27.33 percent boys do not have rule of screen usage only under adult supervision.

Table 3 explains one-way between- groups analysis of variance that was evaluated to explore the impact of rules at home regarding digital devices usage on level of achievement motivation among adolescents. There was a statistically significant difference at the $p<0.05$ level of academic motivation due to screen time rules at home: $F = 1.94$, $p = 0.034$. Therefore, it can be concluded from the above table that rules regarding screen time such as where to watch digital devices, what to watch on these devices, how much time, and frequency of following these rules influence achievement motivation among young generation.

Table 3. Parental regulations regarding screen usage

Statements	Category	Girls (n=150)	Boys (n=150)
When to watch screen	Yes	42.67	44.67
	No	57.33	55.33
Where to watch screen	Yes	26.67	42.00
	No	73.33	58.00
What to watch on screen	Yes	47.33	66.00
	No	52.67	34.00
How much time to watch screen	Yes	44.00	38.67
	Sometimes	28.67	41.33
	No	27.33	20.00
How often do you follow the rules	Never	16.67	20.67
	Rarely	27.33	29.33
	Always	56.33	50.00
Allowed only to watch screen under adult supervision	Yes	34.67	34.67
	Sometimes	31.33	38.00
	No	34.00	27.33

Table 2. Gender differences in the use of Digital gadgets

Digital Gadgets usage	Girls (n=150) Mean ± SD	Boys (n=150) Mean ± SD	Std error	F-Value	Sig. (2-tailed)
Digital gadget cause disturbances in academic activities	1.93 ± .733	1.85 ± .717	0.041	.055	P=0.05
Use for educational purposes	2.16 ± .584	2.06 ± .61	0.034	.498	p>0.05
Hours spent on digital devices to complete school assignments	1.26 ± .586	1.51 ± .75	0.04	20.701	P<0.01
Digital addiction cause lack of concentration	3.086 ± 1.23	3.56 ± 1.40	0.07	5.129	P<0.01
Provide opportunity to improve personality	3.45 ± 1.13862	3.24 ± 1.14	0.06	.261	p>0.05
Encouraged by others' success stories	3.77 ± 1.19	3.54 ± 1.14	0.06	.022	P>0.05
Time spent on digital devices for entertainment	10.15 ± 2.15	10.65 ± 2.28	0.12	.325	P<0.05

Table 4. Effect of parental regulations regarding digital gadgets usage on achievement motivation of adolescents

Achievement motivation	Sum of Squares	df	Mean Square	F	p-value
Between Groups	44.009	11	4.001	1.941	.034
Within Groups	593.578	288	2.061		
Total	637.587	299			

A multiple regression was conducted to predict achievement motivation from the variables digital gadget cause disturbances in academic activities, use for educational purposes, hours spent on digital devices to complete school assignments, excessive screen time cause lack of concentration in classroom, provide opportunity to improve personality and encouraged by success stories of others. All the useful assumptions, including normality, multi-co-linearity and linearity were met. Overall, the regression model was significant, $F = 4.001$, $p<0.001$, $R^2 = 0.76$. Of the independent variables (predators) investigated, disturbances in academic activities due to digital devices ($\beta = -0.127$, $t = -2.23$, $p<0.05$), use of gadgets for educational purpose ($\beta = 0.132$, $t = 2.314$, $p<0.05$), time spent on digital devices for school work ($\beta = 0.113$, $t = 2.25$, $p<0.05$), lack of concentration in classroom because of screen addiction ($\beta = 0.113$, $t = 2.00$, $p<0.05$), and gadgets provide opportunity to improve personality ($\beta= 0.110$, $t = -2.00$, $p<0.05$), were significant. The remaining predator such as and encouraged by success stories of others ($\beta = 0.012$, $t = -0.190$, $p<0.05$), was not significant. Therefore, it can be concluded achievement motivation of adolescents depends on the use of digital devices.

DISCUSSION

The findings reveal that parental rules regarding digital device use for academic and leisure activities significantly influence adolescents' motivation to achieve. Kali (2015) emphasised the importance of parental involvement during adolescence, noting that engaged parents positively impact their children's motivation compared to those with minimal parental guidance. Parent's involvement with their children assists them to be highly motivated to achieve on life as compared to children whose parents do not involve. The study indicates that parental regulations regarding digital device usage at home influence adolescents' achievement motivation. Specific rules were commonly enforced, such as restrictions on where screens can be used, the type of content consumed, and time limits for screen exposure. The findings highlight the frequency with which adolescents adhere to these regulations and their effect on academic motivation.

The study indicates that participants had regulations set by their parents about type of content they exposed to at home. Findings revealed that the parents of the respondents set time limits for screen usage and also highlights how frequently the respondents follow these rules and regulations handed down by their parents. Digital devices help students by providing a wide range of learning opportunities that shape life however; excessive screen time can hinder learning abilities and overall achievement rates. This needs parental rules about screen time that benefit adolescents to focus on their goals without any distraction on these digital media. Parental mediation plays a crucial role in this context, with restrictive mediation negatively affecting online opportunities and risks through digital literacy (Rodríguez-De-Dios et al., 2018). Parental control can help to overcome the harmful impact of prolonged exposure to digital devices. Restrictions on digital devices usage and stimulating relationship with family members when mixed with guidance about age appropriate content can develop a healthy association with digital devices. A study conducted by Rosen et al (2013) suggests that consistent monitoring of adolescents by parents results into better management of their time and goals prioritization. By minimizing distraction on digital platforms, adolescents are able

Table 5. Effect of digital gadgets on the achievement motivation of adolescents

Model		Sum of Squares	df	Mean Square	F	Sig.	R^2	Adjusted R^2
1	Regression	49.313	6	8.219	4.001	0.001[a]	0.076	0.057
	Residual	601.924	293	2.054				
	Total	651.237	299					

[a]Predictors: (Constant), Encouraged by success stories, Disturbances in academic activities, Lack of concentration, Educational purposes, Hours spent on digital devices to complete school assignments, Improved personality, b. Dependent Variable: Achievement Motivation

(b) Coefficients

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. error	B		
(Constant)	4.762	.546		8.727	.000
Digital gadget cause disturbances in academic activities	-.258	.115	-.127	-2.235	.026
Use for educational purposes	.326	.141	.132	2.314	.021
Hours spent on digital devices to complete school assignments	.285	.126	.133	2.257	.025
Excessive screen time cause lack of concentration in classroom	.125	.062	.113	-2.00	.046
Provide opportunity to improve personality	.124	.063	.110	2.001	.046
Encouraged by success stories of others	-.015	.081	-.012	-.190	.849

to concentrate on their academic activities, which may lead to enhance their achievement motivation level. Parental control regarding digital devices usage and achievement motivation also various with different styles of parenting. Padilla Walker and Nelson (2012) in their study conclude that authoritative is one of the most effective parenting style promoting mindful usage of digital devices and achievement motivation among adolescents. As authoritative parenting style is a mixture of love, warmth, responsiveness and clear rules. Authoritarian parenting style is associated with less achievement motivation and high level of digital device addiction (Lilard, 2015).

The study also found that excessive digital device use disrupts academic activities, leading to reduced concentration in classrooms and lower achievement motivation levels. The findings of Kwong & Fong (2019) support the results of the study that the excessive use of electronic devices can lead to academic failure and behavioural problems, negatively impacting adolescents' achievement motivation. Issues such as poor academic performance and interpersonal relationship problems arise from internet addiction, affecting their drive to succeed academically.

Results demonstrate that digital devices used for educational purposes and amount of time spent devoted to finish school assignments significantly affects achievement motivation of adolescents. Consistent with the present outcomes, Baker et al., (2011) highlights that digital device can be beneficial for better learning outcomes when used appropriately. Results show that digital devices provide opportunities to improve personality which in turn influence achievement motivation of participants. Supporting the present study Rodríguez-De-Dios et al., (2018) explored that adolescents with higher digital skills tend to take more online opportunities, which can potentially enhance their achievement motivation However, these digitally skilled adolescents also experience more online risks, highlighting the need for balanced digital engagement. Digital tools provide a wide range of applications including educational apps, online leaning websites and distance education that help in improving academic scores of individuals. These improved intrinsically motivate adolescents to achieve more. Granic et al., (2014) support the results of the present research and suggest that well designed educational games can elevate their motivation level by making learning more cheerful and rewarding. Conversely, Gentile et al., (2011) note that excessive and violent games may lowers motivation by withdrawing from academic pursuits. Adolescence is the transitional period of life and adolescents are easily distracted on these platforms which negatively affect their achievement motivation. The influence whether positive or negative depends on the use of these devices, type of content they expose, duration of digital activities and so on. Results reveal that there are no significant differences in the achievement motivation and digital devices usage among adolescents as per their gender. Research by Murthy & Tauro (2024) explains that a notable association between socio-demographic profile and addiction to smart phones among adolescents but the study does not provide any evidence of gender differences in the use of these devices that support the present study. Contrary to the findings of the present study, Lee et al., (2018) showing gender differences in the use of digital media. These differences may be due to biological, psychological and socio-cultural factors that affect their use of digital devices. Gender specific activities are also present in the use of digital devices. It is observed that males use digital devices for gaming; movies, romantic relationships, and shopping etc while female use these gadgets for conversation with their female friends, fashion and for information purposes. The present study is gender neutral in the aspect of achievement motivation. Wani & Masih (2015) supported these findings, indicating average level of achievement motivation among adolescents irrespective of their gender, type of school and streams they adopted. Bhavna & Kaur (2015) conclude that girls have high level of achievement motivation than boys however, there is less differences in the mean scores.

CONCLUSION

The study highlights the critical role of digital device usage and parental regulations for screen exposure in shaping the achievement motivation of adolescents. The findings suggest that prolonged exposure to digital gadgets can have a destructive effect on adolescents' motivation to achieve something in their lives. Structured time table and consistent parental rules that foster balanced digital exposure enhance achievement motivation among adolescents. Further research should be conducted to explore the long term consequences of digital tools usage and importance of parental interventions in propagating achievement motivation. By understanding the inter-relationship between these factors educationists, parents, policy makers can organize workshops, brainstorming activities, strategy programs for both parents and adolescents that support them to overcome the hurdles of this digital era.

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Investigating Researchers' Skills and Competency Gaps of Agriculture Student: A Needs Assessment Approach

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HIGHLIGHTS

- The study found that technical skills, fund generation and research management were the most significant competency gaps among student researchers.
- Study highlighted software usage, research funding and planning research activities as the top priority areas needing improvement.
- Workshops, mentorship programs, and interdisciplinary collaborations were identified as the best approaches to enhance research skills and bridge competency gaps.
- Improved skills can increase quality publications, conference participation and problem oriented research topic selection among student researchers.

ARTICLE INFO

Keywords: Agriculture education, Borich need assessment, Agriculture research; Technical skills, Research quality, Capacity building.

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ABSTRACT

The study was conducted to understand the important skills and competency gaps of student agriculture researchers for enhancing their research quality. Borich's need assessment model was used, highlighting the needs by studying the difference between relative importance of a research skill and extent of competence. A thorough review of the literature along with experts' advice was conducted, to collect skills needed for agriculture research, reliability was tested (Cronbach's alpha score-0.84) and questionnaire was prepared. The obtained Mean Weighted Discrepancy Scores (MWDS) conveyed that the top three needs of student agriculture researchers were technical excellence (3.19), fund generation (2.98) and management of research activities (2.48). By attaining these skills, respondents perceive fulfilling opportunities such as publishing articles in high-rated journals (82.93%), enhancing the quality of research (78.05%) and attending national and international conferences (72.36%). Based on these results, it could be suggested that agriculture universities organize hands-on experience workshops and training sessions and encourage cross-institutional and cross-border collaborations to help improve agriculture student research activities.

INTRODUCTION

A shift from agriculture to rural development was suggested by Maguire (2000). For this transition to occur, agricultural institutions–actively involved in research, extension, and education–play a crucial role in engaging multiple stakeholders. Agricultural education should focus on individuals' current and future needs rather than the past. With the changing world, these institutions, founded in line with the land-grant institutions of the USA and once operating with stability, now need to be in constant flux as rural development extends beyond technology development. It emphasizes natural resource conservation and requires economic and holistic solutions. Gazi et al., (2009) highlighted the misalignment of agricultural education with the realities of rural life and the

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ultramodern commercial sector. However, the modernization of agriculture shouldn't be confined to the physical and social infrastructure but should also focus on developing agricultural education that will produces trained and skilled graduates (Chaudhary & Pasa, 2015).

The master's and doctoral degrees in agricultural institutions help students find their research identity, a unique self-concept for researchers that may include research self-efficacy and interest. Its key components include confidence, faculty support, researchers' voices, and opportunities (Lamar & Helm, 2017). Furthermore, it is essential to integrate specific skills, abilities, and identities into the curriculum and training during the degree program (Jorgensen & Duncan, 2015). A qualitative analysis by Odena & Burgess (2015) on doctoral students' thesis writing experiences identified out three major themes: customized feedback from the guide/supervisor, personal resilience, and learning strategies. Their study further concluded that while expertise in academic writing is often assumed to be developed independently, the transition across subjects necessitates academic support to meet scholarly expectations.

The number of agriculture postgraduates passing out increases every year and shows a rising trend in India (Agricultural Education, 2016). Agriculture faculty play a crucial role in guiding student researchers toward meaningful studies, prioritizing quality over quantity. They stress the importance of multidisciplinary research, integrating internships and student exchange programs as essential elements (Lynam et al., 2016; Ochs et al., 2017). The goal of agricultural education should be to develop problem-solvers, not just subject matter experts.

When such is the case, the postgraduate education attained must meet the occupational demand to help the student assimilate the knowledge transferred and use it for commercial ends (absorptive capacity) (Rao et al., 1997). Students often view research as merely a degree requirement rather than an opportunity to build expertise. Their focus remains on literature reviews, with minimal emphasis on practical problem-solving or interdisciplinary approaches. Many researchers feel their work lacks impact and express disinterest in research activities (Majidi et al., 2018). There was no exclusive study carried out to analyze the competencies attained by student agriculture researchers.

Understanding the relative importance and competencies of student researchers research skills is vital for universities and policymakers to address gaps and foster quality outcomes that help in shaping educational policies and research frameworks that nurture innovation and engagement.

METHODOLOGY

An exlpratory design was followed to understand the needs of student agriculture researchers, encompassing respondents from all agriculture universities across India. A list of 18 skills which are needed for an agriculture researcher was compiled based on the researchers' experience, literature review, expert discussions, and input from student researchers. The Cronbach's alpha test, performed in MS Excel to measure internal consistency or inter-item homogeneity, yielded a result of 0.84, indicating good reliability (Glen, 2021).

The first set of respondents was contacted through Google Forms based on researcher's familiarity. Later, the form was circulated in relevant WhatsApp groups, and a total of 127 responses were received. After eliminating responses that failed to prove their credibility or showed response errors, 123 responses were retained. Focus group discussion were held to rationalize the obtained responses.

The Borich Needs Assessment model was used in this study to weigh and rank data collected from respondents, addressing limitations of previous studies in evaluating training program success. Unlike tools such as self-reporting (Patil et al., 2024), attitude scales, Q-sort, and Delphi techniques, which are one-dimensional, Borich's model considers both the importance of skills and individuals' competence levels, improving the validity of needs assessment for homogeneous groups (Waters & Haskell, 1989; Elhamoly et al., 2014).

Respondents were asked to rate the importance of agricultural research skills on a five-point scale, from "Very important" to "Not at all important," and their proficiency in these skills, from "Very much proficient" to "Not at all proficient." They also indicated opportunities they believed could arise if these skills were developed. The Mean Weighted Discrepancy Scores (MWDS) were calculated using the following formula:

MWDS = [Σ (Respondents Score for Importance - Respondents Score for Competence) × Importance Mean Score] / Number of Respondents.

Ranks were assigned to individual skills/needs based on the obtained scores, with higher scores indicating greater needs. Factor analysis was performed to group the skills/needs rated as important by the respondents where the suitability of the data was confirmed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. The Bartlett's test of Sphericity was used to test the hypothesis of a correlation between the variables (researcher's skills).

RESULTS

The need assessment among students in research and academic settings is crucial for identifying key areas for improvement and designing appropriate training programs. Understanding skill prioritization and competency levels provides insight into how individuals perceive the importance and proficiency of various research-related competencies and the mean weight discrepancy score obtained and ranked depicts the need (Table 1).

The mean scores indicate the relative importance given by respondents to specific skills. Higher mean scores reflect a higher perceived value for the respective skills, whereas lower scores suggest that respondents did not consider those skills as essential. Top three skills identified as most important by the present study were research management (4.73), commitment (4.73), and writing skills (4.65). These scores highlight that the respondents value the ability to effectively manage research activities, maintain dedication to research tasks, and produce well-structured written outputs.

On the other hand, the least prioritized skills were interdisciplinary collaboration (4.26), fund creation (4.30), and social responsibility (4.40). The relatively lower scores for

Table 1. Needs of student agriculture researchers depicted by Mean Weight Discrepancy Scores (MWDS)

S.No.	Needs of agriculture researcher	Importance Mean Score Value	Competency Mean Score Value	ΣWDS#	MWDS*	Rank
1	Communication skills (Ability to explain your research work)	4.64	4.34	171.75	1.40	13
2	Interdisciplinary collaboration (acting as a team player)	4.26	3.89	195.96	1.59	11
3	Writing skills (able to write articles and reports)	4.65	4.25	227.85	1.85	5
4	Perusing the literature (able to collect extensive content, read and make definitive interpretations)	4.39	4.24	83.41	0.68	18
5	Current affairs (know the latest advancement in your respective fields)	4.45	4.07	209.01	1.70	9
6	Knowledge of different journals and websites	4.46	4.07	218.69	1.78	7
7	Technical excellence (ability to access different software for analysis SPSS, AMOS, MATLAB, R software, etc)	4.57	3.87	392.93	3.19	1
8	Fund creation (avail scholarships and projects)	4.32	3.63	366.95	2.98	2
9	Commitment (dedication towards research activity)	4.73	4.35	222.40	1.81	6
10	Management (planning of research activities)	4.73	4.21	302.85	2.46	3
11	Discipline (able to manage professional and personal lives)	4.50	4.11	215.81	1.75	8
12	Economic research (research topic with practical utility)	4.43	4.05	208.26	1.69	10
13	Resource use efficiency (able to utilize the available infrastructure)	4.53	4.27	144.90	1.18	16
14	Ethical research (Prompt data collection, full disclosure of results)	4.41	4.14	145.43	1.18	15
15	Guidance (Involvement of chairperson in students research activities)	4.58	4.10	270.04	2.19	4
16	Researchers' Integrity (interpretation without data manipulations)	4.42	4.20	123.84	1.01	17
17	Motivation (urge to do better and develop skills for personal betterment)	4.59	4.30	160.48	1.30	14
18	Social responsibility	4.40	4.04	193.51	1.57	12

ΣWDS = [Σ(Respondents score for Importance - Respondents score for competence) × Importance Mean Score], * MWDS= ΣWDS / n

interdisciplinary collaboration suggest that focusing research work within specific departmental areas may hinder broader collaborative thinking. Additionally, readily available infrastructure and research topics lacking practical applicability might be factors contributing to the lower prioritization of fund generation and social responsibility.

The study also examined respondents' proficiency in executing research-related skills. The mean competency scores for certain skills were notably lower, with fund generation (3.63), technical skills (3.87), and interdisciplinary collaboration (3.89) being the weakest areas. For example, the lower competency score in fund generation implies that respondents struggle to secure research grants, possibly due to insufficient training in proposal writing or lack of awareness about funding opportunities.

The discrepancy between the importance of a skill and the ability to perform it highlights gaps in training thereby considered as needs of student agricultural researcher. For instance, while technical skills are considered crucial for research success, the lower competency score indicates a need for more hands-on training and workshops to enhance technical proficiency. According to Borich (1980), insufficient training is indicated when a skill is highly valued but poorly performed. The MWDS reveals these critical gaps, providing valuable insights for program planners to develop targeted training activities. For example, if software proficiency is a key area with a high MWDS, then organizing workshops on data analysis tools such as SPSS, R, or GIS software would be a priority.

The MWDS pinpoints the skills that respondents lack by calculating the difference between perceived importance and actual competency. The top three needs identified through MWDS were the ability to use different software (3.19), availing scholarships and projects (2.98), and planning research activities (2.46).

A study by Ochs et al., (2017) also emphasized the growing importance of software literacy for research, particularly in data analysis and project management. Similarly, He et al., (2019) highlighted the need for training in availing scholarships and securing research projects as critical for academic success. These findings underscore the necessity for targeted training programs to address these gaps.

Previous research by Ramesh et al., (2019) suggested that post-graduate and Ph.D. guidance is the least prioritized training needed for faculty in agricultural universities. However, the present study contradicts this finding. It aligns with research by Odena & Burgess (2015) and Hill & Conceição (2019), which emphasized the importance of guidance from the chairperson in academic research. This finding highlights the need for structured mentorship and support for post-graduate and Ph.D. students.

To further analyze and group the variables (skills) based on their inter-correlations, PCA was employed. PCA helps reduce data dimensionality and identifies underlying patterns among variables. Before conducting factor analysis, preliminary tests were performed to ensure data suitability. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy yielded a commendable value of 0.836, indicating that the sample size and data were suitable for factor analysis. Additionally, Bartlett's test of sphericity confirmed the presence of correlations among variables, signifying the appropriateness of factor analysis (Table 2).

The insights from skill prioritization, competency analysis, and MWDS, combined with PCA, provide a comprehensive understanding of the research skill gaps among respondents. This information is invaluable for developing targeted training programs to enhance research competencies and address existing gaps, thereby fostering a more proficient and collaborative research environment.

Table 2. Preliminary Tests for Factor Analysis - Important skills for agriculture researcher

S.No.	Preliminary Tests for factor analysis	Importance
1	Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.836
2	Bartlett's Test of Sphericity (Approx. Chi-Square)	867.57* (degrees of freedom - 153)

*Significant (p<0.001)

The analysis of agricultural researchers' skills, as depicted in Table 3, highlights the results from a Principal Component Analysis (PCA) (Das et al., 2024) with Direct-Oblimin Rotation (as the component correlation matrix had at least one value greater than 0.32, indicating a significant contribution of variance by factors (greater than 10%), revealing four significant components that account for 57.438% of the variance in skills deemed important by the respondents. The first component, labeled externally aided skills, contributes the highest variance (36.457%) and encompasses fundamental skills necessary for effective research. These include social responsibility (h^2 = 0.812), writing skills (h^2 = 0.702), technical excellence (h^2 = 0.682), and guidance (h^2 = 0.604). Social responsibility, which reflects the researcher's commitment to addressing societal issues, emerged as the most important skill. For instance, an agricultural researcher engaged in developing sustainable farming techniques that also benefit local communities demonstrates social responsibility. Writing skills (h^2 = 0.638) are critical for researchers to effectively communicate their findings to a broader audience, and technical excellence (h^2 = 0.590) is essential for using modern software tools like SPSS or MATLAB for analysis.

The second component, Value-Addition Skills, explains 8.239% of the variance and includes economic research (h^2 = 0.815), ethical research (h^2 = 0.814), interdisciplinary collaboration (h^2 = 0.664), and literature review (h^2 = 0.632). These skills help enhance the quality and applicability of research. Economic research (h^2 = 0.657) is crucial because it bridges the gap between theoretical knowledge and practical application, such as conducting cost-benefit analyses to assess the feasibility of new agricultural technologies. Ethical research (h^2 = 0.682) ensures that data collection is conducted transparently, without manipulation, promoting trustworthiness in the findings. Interdisciplinary collaboration (h^2 = 0.602) fosters cross-disciplinary approaches, such as collaboration between economists, agronomists, and environmental scientists to develop sustainable agricultural practices.

Research Advancement Skills, the third component, explains 6.968% of the variance and consists of knowledge of current affairs (h^2 = 0.778), discipline (h^2 = 0.636), and fund creation (h^2 = 0.542). These skills help researchers stay relevant in their fields and secure the necessary resources for their work. Staying updated on current affairs (h^2 = 0.693) allows researchers to incorporate the latest advancements in their areas of study, such as integrating climate change adaptation strategies into farming practices. Discipline (h^2 = 0.636) ensures that researchers maintain a rigorous approach to both their professional and personal lives, a key factor in sustaining long-term research productivity. Fund creation (h^2 = 0.535) is a

Table 3. Factor Loadings from Principal Component Analysis with Direct Oblimin Rotation for Research skills Importance by the respondents

S. No.	Skills required for agriculture researcher	Components				Commu-nality (h2)
		Factor 1 Externally Aided Skills	Factor 2 Value-Addition Skills	Factor 3 Research Advancement Skills	Factor 4 Management Skills	
1	Management (planning of research activities)				.832	.662
2	Commitment (dedication towards research activity)					.395
3	Interdisciplinary collaboration (acting as a team player)		.664			.602
4	Economic research (research topic with practical utility)		.815			.657
5	Ethical research (Prompt data collection, full disclosure of results)		.814			.682
6	Perusing the literature (able to collect extensive content, read and make definitive interpretations)		.632			.594
7	Current affairs (know the latest advancement in your respective fields)			.778		.693
8	Knowledge of different journals and websites					.538
9	Fund creation (avail scholarships and projects)			.542		.535
10	Guidance (Involvement of chairperson in students research activities)	.604				.489
11	Discipline (able to manage professional and personal lives)			.628		.636
12	Communication skills (Ability to explain your research work)					.425
13	Technical excellence (ability to access different software for analysis SPSS, AMOS, MATLAB, R software, etc)	.682				.590
14	Writing skills (able to write articles and reports)	.702				.638
15	Resource use efficiency (able to utilize the available infrastructure)					.487
16	Researchers' Integrity (interpretation without data manipulations)					.575
17	Motivation (urge to do better and develop skills for personal betterment)					.492
18	Social responsibility	.812				.649
	Eigen Value	6.562	1.483	1.254	1.039	
	% of Variance	36.457	8.239	6.968	5.774	
	Cumulative %	36.457	44.696	51.664	57.438	

critical skill for agricultural researchers, enabling them to secure scholarships and grants for their projects, ensuring continuous research progress.

The Management Skills component, explaining 5.774% of the variance, includes management of research activities ($h^2 = 0.832$), and planning ($h^2 = 0.662$), which are necessary for effective project execution. Management skills help researchers effectively organize their research activities, allocate resources, and coordinate teams, ensuring that research is completed on time and within budget. Given that these skills are highly interrelated, training programs should focus on their complementarity. For example, a training session on research advancement could simultaneously cover current affairs, fund generation, and ethical considerations, all of which are essential for maintaining the relevance and integrity of the research.

In Table 4, respondents were asked about the opportunities they perceive would arise from acquiring these skills. The top three opportunities included publishing articles in high-rated journals (82.93%), enhancing the quality of research (78.05%), and attending national and international conferences (72.36%). Publishing in prestigious journals is often seen as a key indicator of a researcher's success, and acquiring these skills enables researchers to present their work at a global level. Enhancing the quality of research (78.05%) is another major benefit, as it directly impacts the credibility and impact of the research in the academic and professional communities. Finally, attending national and international conferences (72.36%) provides a platform for networking, learning from peers, and sharing research findings, which can further propel a researcher's career and foster new collaborations.

Table 4. Opportunities perceived to be attained by respondents when skills are improved (n=123)

S.No.	Opportunities	Percentage
1	Attend several national and international conferences	72.36
2	Pursue multi-disciplinary research	66.67
3	Attain scholarships and stipends	67.48
4	Publish articles in high-rated journals	82.93
5	Betterment in research area selection	64.23
6	Increased research motivation	57.72
7	Overall personality development	67.48
8	Enhancement of quality of research	78.05
9	Better interpretation of data	63.41
10	Involvement in student exchange programs	51.22

Other opportunities include pursuing multi-disciplinary research (66.67%), attaining scholarships and stipends (67.48%), and betterment in research area selection (64.23%). These opportunities underscore the broader career and personal development benefits (Sikdar and Prakash, 2025) that come with mastering these skills, contributing to a researcher's growth and recognition in the agricultural field.

DISCUSSION

Focus group discussions with student agriculture researchers reveal important insights into the factors influencing the self-reliance and professional development. Higher self-reliance among the respondents can be attributed to the fact that individuals with higher levels of education, particularly in agricultural sciences, tend to have increased confidence in their abilities. These individuals are not only aware of external factors beyond their control, but they also rely on their personal efforts and capabilities to achieve their goals.

Internships play a crucial role in bridging the gap between theoretical knowledge and practical application, offering students valuable opportunities to engage in real-world problem-solving. By immersing themselves in agricultural scenarios, students gain firsthand experience in field research, interact with professionals, and develop essential skills for addressing complex challenges. For instance, internships with NABARD have provided students with insights into agricultural finance, rural development, and farmers' socio-economic conditions. These experiences not only enhanced their understanding of real-world agricultural issues but also guided them in selecting more focused and impactful research topics for their academic work.

Interestingly, no student researchers reported disinterest in internships or workshops, highlighting a strong enthusiasm for experiential learning. This aligns with the observation by Rao et al., (1997) that integrating practical exposure into agricultural education can help shift away from traditional state-controlled models by fostering collaboration with the private sector and research organizations. Such partnerships create a mutually beneficial environment, where students gain problem-solving skills, and industries benefit from their fresh insights (Aba et al., 2015). Emphasizing internships and workshops within the curriculum can therefore enhance student engagement in research-related activities, promoting a more inquiry-driven mindset and preparing future professionals to address agricultural challenges effectively. In addition to internships, the study also emphasizes the importance of excelling in research activities within defined time frames. Student researchers are expected to produce high-quality, plagiarism-free synopses and theses while also contributing to academic knowledge through publishing articles. This requirement highlights the critical role of writing skills, which ranked highly among the respondents. The ability to write effectively is essential for translating complex research into clear and compelling academic papers, which can be shared with a wider scientific community. Writing skills are fundamental to disseminating research findings, and as such, they are considered indispensable for student researchers aiming to succeed in academia (Yadav & Mehta, 2020).

While data availability is a starting point for research, the way data is processed and analyzed significantly influences the quality of the final research output. The respondents ranked software skills highly, underscoring the importance of being proficient with advanced analytical tools (Gouseti, 2017) and software, such as SPSS, MATLAB, and R. These tools enable researchers to analyze data more efficiently and derive insights that are not only valuable but also contribute to the originality and rigor of the research. For instance, advanced statistical software allows researchers to handle large datasets, perform complex analyses, and generate findings that may not be immediately apparent through traditional methods. Alongside technical skills, fund-generation skills were identified as

another critical area of need. Fund generation ranked second on the list, emphasizing its importance in supporting long-term research endeavors. Funding is essential for sustaining research activities, acquiring necessary resources, and facilitating the execution of comprehensive projects. A well-funded research program enables students to pursue ambitious research ideas, acquire advanced tools and equipment, and participate in relevant conferences and workshops that further their academic and professional development.

The significance of fund generation is supported by the findings of Ochs et al., (2017), who highlighted the importance of publishing in high-impact journals as a primary research outcome for faculty engaged in agricultural research. This urge to publish in prestigious journals extends to student researchers as well, who recognize the importance of disseminating their findings in top-tier publications to enhance their academic standing. The results from Table 4 align with this perspective, as publishing articles in high-rated journals (82.93%) was the most sought-after outcome (Horta & Li, 2022), followed by enhancing the quality of research (78.05%) and attending national and international conferences (72.36%). Publishing in high-impact journals requires not only high-quality research but also the ability to analyze data effectively and present it in a clear and compelling manner. By attending conferences, student researchers can gain exposure to cutting-edge research, share their findings with experts in the field, and build their professional networks. However, the costs associated with attending such events and publishing in high-quality journals often require external funding, further emphasizing the need for fund-generation skills. Enhancing the skills of agricultural student researchers through internships, workshops, and training programs is essential for fostering a research-oriented mindset and improving the quality of research outputs. By addressing the identified skill gaps, particularly in technical proficiency, fund generation, and research management, institutions can better prepare students for successful careers in agricultural research and contribute to solving pressing agricultural challenges.

CONCLUSION

Understanding and addressing the needs of student agriculture researchers, agricultural institutions can contribute to the development of feasible and applicable technology and policy interventions. This, in turn, leads to the improvement of the entire research ecosystem. It recommends conducting similar assessments among faculties of state agriculture universities or other research organizations to gain a comprehensive understanding of the needs and enhance the overall quality of research in the agricultural sciences.

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Research Article

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Growth Dynamics and Sustainability of Major Crops in Haryana, India

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HIGHLIGHTS

- Rice cultivation shows significant groundwater dependence, posing sustainability challenges.
- Government policies like "Mera Pani Meri Virasat" promoted water-efficient crops post-2015.
- Instability is low for wheat and rice, high for sugarcane and gram.

ARTICLE INFO

Keywords: Agricultural sustainability, Crop diversification, Groundwater depletion, Water-efficient Crops, Yield instability.

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ABSTRACT

The study examined the nexus between crop growth, instability, and groundwater depletion in Haryana, India. Data was collected for 2002 to 2022 to examine the trends of cropped area, production, and productivity by calculating compound annual growth (CAGR). The drivers of crop growth and instability in area, production, and productivity using decomposition analysis and the Cuddy-Della Valle Instability index, were examined respectively. Finally, the Pearson and Spearman correlation methods to investigate the relationship between groundwater depletion and crop yield were employed. Consistent production growth in wheat and rice but negative growth in gram and cotton production observed. After 2015, bajra and rapeseed-mustard showed big improvements, indicating success of programs like "Mera Pani Meri Virasat" that encourage water-efficient farming. Instability analysis indicated low variability in wheat and rice yields but high instability in sugarcane and gram. Gram's resistance to low water levels and rice's strong reliance on groundwater were both brought to light by correlation analysis. The findings stress the importance of crop diversification, especially promoting gram production, and suggest targeted interventions in yield enhancement for sustainable agricultural development.

INTRODUCTION

In India, agriculture and its related sectors offer the majority of livelihoods, especially in the country's vast rural areas. Agriculture remains a cornerstone of India's rural economy, contributing approximately 17.70 per cent to the country's Gross Value Added (GVA) in 2023-24 (GoI, 2024). According to the Periodic Labour Force Survey (PLFS), the proportion of India's workforce engaged in agriculture and allied sectors was 45.50 per cent in 2022–23 (MoSPI, 2023). In the last few years, India has also become a net exporter of agricultural products. Haryana, known for its extensive fertile land, has emerged as a significant contributor to India's agricultural and industrial sectors. Agriculture directly employs about 70 per cent of people in the agrarian state of Haryana (Swati, 2024). One of its primary crops is wheat. It significantly contributes to the country's food basket.

The state has achieved substantial progress in its agricultural development, making it self-sufficient in food grain production and making it the second-largest contributor to the central food grain pool in India (Sihmar, 2014; Nisha et al., 2019). Haryana alone accounts for almost 60 per cent of the world's exports of basmati rice. Wheat and paddy crops accounted for 61.40 per cent of the state's total gross area in 2022–2023, according to the Economic Survey of Haryana, 2024. In the Indo-Gangetic Plain region of India,

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farmers have used climate-smart agriculture practices, such as improved crop varieties, laser field levelling, and zero tillage, which have raised farm output and reduced production costs (Jatav & Mubeena, 2024). However, agriculture in the region, including Haryana, faces severe challenges, including imbalances in water resources, degraded land, inefficient input utilization, declining factor productivity, high production costs, a lack of workforce, and low farmer returns (Bishnoi et al., 2015). Therefore, the Haryana government has launched an ambitious programme called "Mera Pani Meri Virasat" to diversify the cropping pattern from water-intensive crops (i.e., wheat, rice, and sugarcane) to water-efficient crops (i.e., pulses, bajra, maize, and cotton) to maintain the state's groundwater level (Kumar & Phougat, 2022).

Lastly, it is evident that cropped area and production are fluctuating over the year, and to control the fluctuations, farmers are using relatively more groundwater. This leads to a severe water crisis for both agriculture and domestic use. Therefore, it is a prerequisite to examine the nexus between cropped growth, instability, and groundwater depletion in most food-producing state of India, namely Haryana. Further, identification of drivers of crop growth is also vital for sustainable agricultural practices; therefore, this study uses large-scale data from 2002 to 2022 to identify the key drivers of crop growth in Haryana using decomposition analysis. The findings from this study provide critical insights for policymakers and stakeholders to develop strategies that enhance productivity while ensuring long-term resource sustainability.

METHODOLOGY

The present study used secondary data collected from the Department of Agriculture and Farmer Welfare, Haryana, covering major food and non-food crops for the period of twenty-one years ranging from 2002 to 2022. The data on growth of cropped area, production and productivity was analysed using compound annual growth rate. Further, instability in cropped area, production and productivity was measured using the coefficient of variation and the Cuddy-Della Valle Index (eq. 1).

$$\text{Cuddy-Della Valle Index} = C.V \times \sqrt{(1-R^2)} \quad ...(1)$$

Where, C.V. stands for Coefficient of Variation and $R^2$is the coefficient of determination obtained from a regression analysis on the time series data. The instability classification followed Sihmar (2014), categorizing instability as low (0-15), medium (15-30), and high (>30).

To assess the contribution of area, productivity, and their interaction to total production, the decomposition method was applied (Kalia et al., 2021), Several studies used this decomposition analysis and studied growth performance of crops (Bhatnagar & Saxena, 2000; Siju & Kombairaju, 2001).

$$P_n - P_o = (Y_n - Y_o) A_o + (A_n - A_o) Y_o + (Y_n - Y_o) (A_n - A_o) \quad ...(2)$$

$$\Delta P = (\Delta Y) A_o + (\Delta A) Y_o + (\Delta Y) (\Delta A) \quad ...(3)$$

Where, P_n, Y_n and A_n are the production, yield and area under crop in the current period respectively and P_o, Y_o and A_o are the production, yield and area under crop in the base period, respectively. ΔA = change in area between current year and base year, ΔY = change in yield between current year and base year.

To examine the relationship between groundwater depth and crop production, Pearson's correlation coefficient and Spearman's rank correlation was used. Further, Pearson's correlation coefficient was used to examine correlation between yield of rice, bajra, wheat, gram and cotton with groundwater depth, as data is normally distributed, while spearman's rank correlation was used to examine relationship between yield of rapeseed & mustard & sugarcane with groundwater depth.

RESULTS

Growth in the area, production, and productivity of major crops

The Compound Annual Growth Rate (CAGR) has been examined to evaluate the long-term trends in the area, output, and productivity of key crops from 2002 to 2022. The investigation is segmented into three separate stages to enhance comprehension of development variances. Table 1 displays the CAGR estimates, emphasizing both favourable and unfavourable trends across various crops, shaped by factors such as policy interventions, environmental circumstances, and technology improvements. The analysis of the CAGR for the region indicates, as shown in Table 1, that the CAGR is positive for rice, wheat, and rapeseed & mustard, while it is negative for sugarcane, bajra, gram, and cotton. The region exhibits the most significant positive increase for rice, whereas the most pronounced negative growth is seen for gram. Since 2015, there has been notable expansion in the area, output, and productivity of gram.

Similarly, the compound annual growth rate (CAGR) of production is positive from 2002 to 2022 for rice, wheat, sugarcane, bajra, rapeseed, and mustard, whereas production growth is negative for gram and cotton (Table 1). Rice output has the most significant positive development, followed by rapeseed and mustard, while grams show the most substantial negative decline. Moreover, there has been a significant increase in the area, productivity, and production of rapeseed and mustard attributed to the promotion of water-intensive crops since 2015. In contrast, bajra has experienced a positive growth rate in area and production due to government initiatives and encouragement for millet cultivation.

All crops under examination have shown favourable growth, with the exception of cotton. The yield of cotton has decreased throughout time. The most significant productivity gain is recorded in rapeseed and mustard, whereas the least favourable rise is noted in wheat (Table 1). Groundwater shortage, environmental stress, and stagnant practices have led to the decline in rice production (Dhanda et al., 2022). The exhaustion of water resources for rice production may result in soil quality deterioration and diminished agricultural yield (Pathak et al., 2011). Excessive use of water resources might exacerbate salinization and waterlogging, hence diminishing agricultural production (Surendran et al., 2021).

Instability in area, production, productivity of major crops

Agricultural instability denotes variations in output, yield, and arable land, which profoundly affect food security, economic stability, and livelihoods (Dalal et al., 2024). Analyzing instability is crucial for comprehending the resilience of various crops due to its significant influence (Tripathi et al., 2023). Table 2 illustrates

Table 1. CAGR of Major Crops

Periods	Rice	Wheat	Bajra	Gram	Rapeseed & Mustard	Cotton	Sugarcane
CAGR in per cent (Area)							
Phase – I	1.58	1.05	2.15	2.02	-0.46	2.32	-4.27
Phase – II	0.68	-0.73	-8.70	-9.72	-0.08	-5.37	2.88
Phase – III	2.40	-1.69	5.31	0.74	8.10	-2.25	0.71
Overall	2.49	0.40	-1.60	-6.36	0.25	-1.32	-2.38
CAGR in per cent (Production)							
Phase – I	1.05	1.27	8.80	-4.20	-2.78	-15.55	-1.58
Phase – II	-0.73	0.19	-6.98	-12.91	-2.49	-1.95	17.86
Phase – III	-1.69	-1.51	11.08	6.62	10.19	-5.68	1.95
Overall	0.40	1.44	1.52	-4.24	2.63	-2.12	0.00
CAGR in per cent (Yield)							
Phase – I	4.22	0.23	6.54	-6.18	-2.38	-18.27	2.81
Phase – II	2.62	0.93	1.95	-3.51	-2.41	3.24	14.55
Phase – III	2.64	0.18	5.53	5.79	1.90	-3.30	1.23
Overall	1.14	1.03	3.17	2.27	2.37	-0.79	2.44

Source: Author's calculation, 2024.

Note: Phase – 1 covers period of 2001-2002 to 2007-08, Phase – II covers of 2008-09 to 2014-15, Phase – III covers of 2015-16 to 2021-22, and overall indicates period of 2001-02 to 2021-22.

the projected volatility for principal crops, indicating diverse levels of variation in area, output, and yield during the research period. The research revealed that during its duration, there was little volatility in the area of wheat, rice, and bajra. Cotton, rapeseed, mustard, sugarcane, and gram followed, demonstrating a moderate degree of fragility. The cultivation of rice and wheat has a consistent pattern. The analysis indicated little variation in the production of rice and wheat over this period, whereas cotton, bajra, rapeseed, and mustard exhibited moderate levels of volatility. Sugarcane and gram had significant volatility over the mentioned period. The research demonstrates little variation in the yields of wheat, rice, bajra, rapeseed, and mustard over the study period, but cotton, sugarcane, and gram exhibited a moderate degree of instability.

Decomposition analysis of production of major crops

To examine the influence of area, productivity, and their interaction on the variability of total output, decomposition methods were used to analyze production variability into its constituent elements. The decomposition study of production variations across principal crops from 2002 to 2022 underscores the substantial impacts of area and yield effects, whereas interaction effects are comparably negligible. In the case of crops such as rapeseed-mustard and bajra, the area impact was a crucial factor, considerably influencing Phase-I and Phase-III (Table 3). Likewise, sugarcane exhibited a remarkably significant area impact during the whole duration, signifying that production increase was mostly propelled by the enlargement of farmed regions (Table 3). Conversely, wheat had significant contributions from both yield and area impacts, indicating balanced growth determinants. Nonetheless, crops such as sugarcane had a significant adverse influence on yields, highlighting difficulties in enhancing productivity for specific crops. This highlights the need of focused interventions in yield improvement and optimal land use to maintain long-term production growth.

Major crop production and groundwater depth

Two correlation approaches were used to examine the association between groundwater depth obtained from the Central Ground Water Board and the Ground Water Cell of the Irrigation and Water Resource Department of Haryana (2023), and crop production. We used the Pearson correlation coefficient and the Shapiro-Wilk test, contingent upon the normality of the data. Rice exhibited a robust positive and significant connection with groundwater depth, indicating its substantial reliance on groundwater and the need for considerable water for cultivation (Table 4). Wheat exhibited considerable water dependency, demonstrating a positive and significant connection. Gram had a significant negative association, suggesting it thrives with less water

Table 2. Instability in Area, Production and Productivity of major crops

Crops	Area	Intensity	Production	Intensity	Yield	Intensity
Rice	4.14	Low	5.28	Low	6.16	Low
Wheat	3.78	Low	8.36	Low	6.56	Low
Bajra	14.67	Low	23.24	Medium	12.18	Low
Sugarcane	18.57	Medium	36.20	High	29.99	Medium
Gram	27.27	Medium	34.78	High	20.91	Medium
Rapeseed & Mustard	15.95	Medium	18.66	Medium	11.86	Low
Cotton	10.40	Medium	24.30	Medium	27.53	Medium

Source: Author's calculation, 2024.

Table 3. Decomposition of Production of major crops

Decomposition (in Percentage)	Rice	Wheat	Bajra	Gram	Rapeseed & Mustard	Cotton	Sugarcane
Phase – I							
Area effect	13.58	18.64	83.00	44.25	29.38	-14.53	285.08
Yield effect	82.79	75.85	15.89	74.00	76.31	149.43	-212.53
Interaction effect	3.63	5.51	1.11	-18.25	-5.69	-34.89	27.45
Phase – II							
Area effect	0.26	96.54	-85.14	70.66	28.74	1012.23	13.05
Yield effect	0.70	5.39	173.40	56.64	76.31	-643.05	83.24
Interaction effect	0.04	-1.93	11.74	-27.30	-5.05	-269.18	3.72
Phase – III							
Area effect	40.49	-0.83	133.65	-12.60	68.96	4.90	58.74
Yield effect	52.47	101.09	-37.52	124.31	18.04	92.51	35.98
Interaction effect	7.04	-0.26	3.86	-11.70	13.00	2.59	5.28
Overall (2002-22)							
Area effect	48.24	-42.08	4.28	116.77	57.70	0.38	591.57
Yield effect	34.66	168.69	95.27	-62.81	25.91	99.19	-742.88
Interaction effect	17.10	-26.61	0.45	46.04	16.38	0.44	251.31

Source: Author's calculation, 2024.

Note: Phase – 1 covers period of 2001-2002 to 2007-08, Phase – II covers of 2008-09 to 2014-15, Phase – III covers of 2015-16 to 2021-22, and overall indicates period of 2001-02 to 2021-22.

Table 4. Correlation matrix between crops production and groundwater depth

Pearson Correlations	Groundwater Depth (meters)
Rice	0.796**
Bajra	0.318
Wheat	0.563**
Gram	-0.639**
Cotton	0.252
Spearman's rho Correlations	
Rapeseed & Mustard	0.519*
Sugarcane	-0.051

Source: Author's Calculations, 2024. * & ** indicates 5 per cent and 1 per cent level of significance

availability; hence, it serves as a valuable alternative to wheat and rice for enhancing groundwater levels. Rapeseed and mustard have moderate water demands, but sugarcane and bajra demonstrate little or negligible reliance on groundwater. These results underscore rice as the most water-intensive crop among those examined.

DISCUSSION

Sustainability in agriculture is a multifaceted concept encompassing economic viability (a sustainable farm must be a profitable enterprise that bolsters the economy), social equity (it should treat its workers justly and foster a mutually advantageous relationship with the local community), and environmental stewardship. Sustainability entails the ethical management of natural systems and resources essential for agriculture by fostering and preserving good soil, judiciously managing water, reducing pollution in air, water, and climate, and enhancing biodiversity. Haryana is a classical case for sustainable farm practices, as it is rich in water and soil resources and suitable for high-value crops. The post-green revolution (1960-1990s) and post-economic reform periods (1991-2000s) further validated this. Crop areas under high-yield varieties in Haryana needed more water, fertilizer, and pesticides. Singh et al., (2021) found that Haryana's per-hectare consumption of fertilizers was 56 percent higher than that of the country as a whole. The results of this study aligned with the findings of Bishnoi et al., (2015). Their findings revealed that agriculture in Haryana faces significant challenges, including imbalances in water resources, soil degradation, inefficient input utilisation, declining factor productivity, elevated production costs, labour shortages, and minimal returns for farmers.

With subsidized chemical fertilizers and a free water supply, farmers tend to grow more water-intensive crops like wheat, rice, and sugarcane, leading to fluctuation in the cropped area and yield of minor cereals and pulses. Panwar & Dimri (2018) have confirmed this. They have used large-scale data from 1966–67 to 2015–16 on cropping area, production, and yield. They found that the yield of major crops like wheat, rice, sugarcane, and cotton increased progressively due to the adoption of high-tech agricultural practices. Further, the current study analyzed the instability in the cropped area, production, and productivity of major crops, concluding that there is significant instability in all of them. These findings were also aligned with those of Swati (2014). She found that a decrease in yield instability can lead to a reduction in both area instability and production instability. It was also in line with what Kalia et al., (2021) found, which is that area and yield effects have the most impact on production growth, while interaction effects have a smaller impact.

CONCLUSION

This study highlights the nexus between agricultural growth, instability issues in yield, and the rise in groundwater issues. The findings revealed that major food crops, viz., rice, wheat, and bajra, are maintained in stable cultivation, while non-food crops, viz.,

cotton and sugarcane, exhibited moderate to high fluctuations, indicating vulnerability to external factors, especially rainfall and temperature. Similarly, the correlation between crop production and groundwater depth reinforces this challenge, with rice showing a strong dependence on water resources, while gram was more resilient under limited water availability. Therefore, the evidence suggests that there is a need for a grassroots-level water management policy that enables addressing regional issues. Further, for long-term agriculture sustainability, a shift toward yield enhancement strategies, efficient resource utilization, and targeted interventions to balance productivity with environmental conservation are vital for sustainable development agriculture planning.

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Research Article

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Knowledge, Attitudes, and Practices in Sustainable Nutrition in Late Adulthood- A Qualitative Analysis

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HIGHLIGHTS

- Investigates the knowledge, attitude, and practices (KAP) of sustainable nutrition among Jaipur residents aged 50 and above.
- Uses qualitative research through semi-structured interviews to explore food choices, purchasing behaviour, and environmental awareness.
- Finds that traditional food habits influence sustainability, but modern convenience trends pose challenges.
- Suggests the need for targeted education to improve sustainable dietary practices among older adults.

ARTICLE INFO

Keywords: Sustainable nutrition, Late adulthood, Food choices, Carbon footprint, Knowledge-Attitude-Practice (KAP).

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ABSTRACT

Sustainable nutrition is the need of the hour to ensure optimal health without jeopardizing the needs of the upcoming generations. This study, conducted in 2024, investigates the knowledge, attitudes, and practices (KAP) pertaining to sustainable nutrition among individuals in late adulthood (above the age of 50). A sample of 20 residents of Jaipur city, above the age of 50 years, was chosen and a qualitative research design was used. In-depth, semi-structured interviews were conducted to understand the participants' approach as well as knowledge of sustainable nutrition, their dietary habits, food purchasing decisions and the factors influencing their food choices. The study revealed that participants understand the importance and need of sustainable nutrition practices, yet they do not reflect this sense of responsibility in their choices. The discrepancy between the two owes to multiple factors including convenience, accessibility issues and a high purchasing power. The impact of this study extends beyond understanding the behavioural patterns of the individuals in their late adulthood. By identifying the knowledge gaps, efforts can be channelised towards developing educational programs that encourage wiser, more sensitive, and informed choices among this age group.

INTRODUCTION

The significance of sustainable nutrition has grown as communities aim to integrate health-conscious eating with environmental conservation. This concept emphasizes the consumption of foods with a lower ecological footprint by reducing carbon emissions, optimizing waste disposal, and promoting local food production (Ruini et al., 2015). Such dietary choices enhance personal health and ensure the preservation of natural resources for future generations (Guillaumie et al., 2020). Environmental changes affect agriculture and food production, while food choices, in turn, influence the environment, creating a continuous and reinforcing cycle, making sustainable nutrition choices crucial (Ghanghas et al., 2015; Kumar & Saxena, 2024)

In India, traditional diets inherently support sustainability, but contemporary consumer preferences, shaped by socio-economic status, cultural influences, and convenience, have led to varying levels of adherence to sustainable dietary practices (Kumar et al., 2022). The increasing reliance on processed and packaged foods due to globalization and urbanization has created sustainability concerns

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(Gupta et al., 2022). Individuals in late adulthood (50 years and above) play a critical role in shaping household food choices and influencing younger generations. Despite growing environmental awareness, the extent to which this age group integrates sustainable choices into daily life remains unclear. Accessibility, financial stability, health concerns, and traditional preferences influence their decision-making (Criss et al., 2020). Older adults have been found to not only possess nutrition-related knowledge but also apply it in their dietary practices, highlighting the potential of interventions targeting this group (Jeruszka-Bielak et al., 2018). Research in Poland further indicated that individuals aged 55+ engaged in sustainable food purchasing, driven by personal norms and environmental awareness (Podgórniak-Krzykacz & Przywojska, 2025).

Sustainable nutrition involves dietary habits that support human health and environmental conservation, ensuring future resource availability (Perignon et al., 2017). Emphasizing plant-based diets can enhance sustainability by reducing carbon footprints and encouraging efficient waste management (Viroli et al., 2023). However, the dietary transition towards convenience foods contributes to a greater environmental burden, necessitating initiatives promoting sustainable eating (Jackson & Viehoff, 2016). The KAP model, widely used in public health, helps assess individuals' understanding, attitudes, and behaviors regarding sustainability, facilitating targeted interventions (Zarei et al., 2024). A study in Spain highlighted that misinformation hinders sustainable food consumption, emphasizing the necessity of structured education programs (García-González et al., 2022).

Assessing KAP can help develop sustainability-focused initiatives promoting responsible food choices. Community-supported agriculture programs encourage local and organic food consumption and contribute to environmentally conscious decisions (Vasquez et al., 2016). Despite global research emphasizing the positive influence of knowledge on sustainable practices, limited studies focus on India's older population. Understanding their KAP can inform policymakers and public health efforts, fostering long-term behavioral changes that support both human health and environmental conservation.

METHODOLOGY

The qualitative study aimed to explore the knowledge, attitudes, and practices (KAP) of sustainable nutrition among individuals in late adulthood (aged 50 and above) residing in Jaipur, Rajasthan. A purposive sampling approach was used to recruit 20 participants from diverse backgrounds, ensuring a broad representation of perspectives on sustainable nutrition practices. Participants were selected based on their willingness to share their experiences and insights related to food choices, waste management, and environmentally conscious behaviours. The study included 20 respondents aged 50 and above from Jaipur city, representing a diverse demographic in terms of family structure, occupation, and lifestyle. All participants were graduates, belonging to middle-class to upper-middle-class socioeconomic backgrounds. The sample comprised both men and women, engaged in various professions, including teaching, business, government service, and homemaking. All respondents were married, with some living in joint families and others in nuclear households.

Data were gathered through in-depth, semi-structured interviews, allowing participants to share their perspectives openly while maintaining a structured format for comparability across responses. The interview guide included questions on key areas such food sourcing and preferences (local vs. imported produce), waste management practices (reuse of leftovers, food wastage), food packaging and purchasing habits (use of plastic bags, preference for packaged vs. unpackaged goods) and cooking methods and sustainability (use of pressure cookers vs. open pans, energy efficiency). Each interview lasted approximately 30–45 minutes and was conducted in Hindi or English, depending on the participant's preference. The interviews were audio-recorded with consent, transcribed verbatim, and anonymized to maintain participant confidentiality.

A thematic analysis approach was employed to identify recurring patterns in participants' responses, following Braun and Clarke's (2006) six-step framework. First, familiarization with the data was achieved through repeated reading of transcripts to develop an in-depth understanding. Next, initial codes were generated by assigning meaningful labels to key concepts emerging from the data. This was followed by the identification of broader themes and sub-themes relevant to sustainable nutrition. The themes were then reviewed, refined, and validated based on their coherence and relevance. Once finalized, each theme was clearly defined and named to ensure it accurately reflected the data. Finally, the findings were structured into a coherent narrative to support the discussion (Braun and Clarke, 2006).

RESULTS

Thematic analysis yielded several significant insights into participants' sustainable nutrition knowledge, attitudes, and practices. Key themes and sub-themes, along with direct quotes from the participants, are presented below:

Table 1. THEME-1 Preference between locally grown and or imported fruits/vegetables

Sub-themes	Quotes
Freshness	"Locally grown fruits and vegetables are fresher because imported produce has to travel a long distance. So, we should consume locally grown produce." (Respondent 3, F, 57 years, Housewife) "I prefer consuming only fresh fruits and vegetables which is why I purchase local produce." (Respondent 1, M, 59 years, Teacher) "I purchase local produce because the imported produce seems stale and does not taste that good." (Respondent 18, F, 59 years, Housewife)

Table 1 contd...

Sub-themes	Quotes
Impact on health	"I purchase locally grown fruits and vegetables because the imported ones are grown with lots of pesticides which are very harmful for our health." (Respondent 9, F, 54 years, Teacher) "I prefer purchasing locally grown fruits and vegetables because I think they are grown naturally and are safe to consume."(Respondent 6, M, 58 years, Govt. Job) "I buy both imported and local produce because we get different nutrients in different types of foods so we should consume both the kinds." (Respondent 12, M, 63 years, Retired)
Money	"Local fruits and vegetables are cheaper because they don't come from far away, so no extra cost is added." (Respondent 3, F, 57 years, Housewife) "I think that purchasing local produce is better because you can get more quantity with less money." (Respondent 13, F, 62 years, Teacher)"I purchase locally grown fruits and vegetables because they are cheaper and healthier." (Respondent 8, F, 60 years, Housewife)
Quality	"Imported produce loses its nutritional content because of transport time so it is not very good for health." (Respondent 14, M, 58 years, Teacher) "If I see good quality imported fruits, I prefer buying them along with the locally grown ones too. For vegetables, I prefer locally grown ones because of my taste preferences". (Respondent 2, M, 62 years, Businessman) "I check the quality of the fruits and vegetables and based on that I buy both imported and local produce." (Respondent 12, M, 63 years, Retired)
Sustainability	"I believe there is a positive impact, of purchasing local produce, on the environment. However, I do not know how it impacts the environment." (Respondent 7, F, 57 years, Housewife) "I don't think purchasing locally grown fruits and vegetables impacts the environment in any way but I believe in supporting our local farmers." (Respondent 4, F, 59 years, Teacher) "I don't really consider the environmental impact while purchasing fruits and vegetables. I buy based on preference." (Respondent 17, F, 59 years, Govt. Job)

Table 2. THEME 2- Consumption of leftovers in the next meal

Sub-themes	Quotes
Preference of freshly cooked food over stale food	"I have heard that eating stale food is not very good for health so I don't consume leftover food." (Respondent 20, M, 64 years, Retired) "I don't like eating leftovers because I feel they lose their fresh taste." (Respondent 8, F, 60 years, Housewife) "I usually cook in the appropriate portion size. In case, any food is left, we give it away to somebody or feed it to stray animals because I and my family do not like consuming stale food." (Respondent 15, F, 53 years, Govt. Job)
Reduce food wastage	"I consume leftover food in the next meal to avoid food wastage. We keep the food in refrigerator so it doesn't get spoilt." (Respondent 10, F, 57 years, Teacher) "I feel bad throwing food because a lot of people don't even have enough food to eat. So, I prefer making new dishes out of the leftovers." (Respondent 13, F, 62 years, Teacher) "I often use the leftover breads from last night and consume them with buttermilk in breakfast. It tastes good and I don't have to throw away food." (Respondent 5, F, 50 years, Housewife)

Table 3. THEME 3- Using personal grocery bags vs polyethene sold by vendors

Sub-themes	Quotes
Durability	"The polybags are made of very thin material but our personal bags are made of strong cloth which does not tear so it is a better option." (Respondent 16, M, 56 years, Businessman) "I prefer taking my own bag for purchasing grocery items because the poly bags provided by vendors are not so durable. They don't have a good holding capacity." (Respondent 19, F, 58 years, Housewife) "I take my own bag for shopping because I can carry much more weight in it. The polythene sold by vendors cannot hold a lot of items and so we need to take multiple bags from the vendor." (Respondent 10, F, 57 years, Teacher)

Table 3 contd...

Sub-themes	Quotes
Impact on health	"I have heard about microplastics and how they can get into our food as well. So, I don't prefer the polythene bags." (Respondent 12, M, 63 years, Retired) "I always take my own cloth bag because keeping food in plastic bags is harmful for our health as the plastic goes into our body when we eat that food." (Respondent 11, F, 58 years, Housewife)" I carry my own cloth bag because I can keep it in a clean condition. The polythene provided by vendors is not clean and it can make us ill." (Respondent 5, F, 50 years, Housewife)

Table 4. THEME 4- Purchasing unpackaged (loose) grocery items

Sub-themes	Quotes
Risk of adulteration	"Unpackaged items are not safe to consume because they come in contact with dirt and insects." (Respondent 13, F, 62 years, Teacher) "I barely purchase any unpackaged item except rice that comes in a sack. I don't think that unpackaged items are safe for consumption." (Respondent 5, F, 50 years, Housewife) "I buy only packaged food items because I can be sure of the quality in that case." (Respondent 4, F, 59 years, Teacher)
Preference for traditional choices	"Packaged items have so many preservatives whereas local items don't have preservatives which is why I purchase them." (Respondent 6, M, 58 years, Govt. Job) "I prefer buying unpackaged cereals and pulses because my parents also used to do the same." (Respondent 8, F, 60 years, Housewife) "I usually buy unpackaged items because they are not processed as much as the packed ones." (Respondent 14, M, 58 years, Teacher)

Table 5. THEME 5- Opinion on the packaging used by food delivery systems

Sub-themes	Quotes
Convenience	"If companies will use paper packaging, then the food is going to spill. So, using plastic packaging is necessary for cooked food." (Respondent 2, M, 62 years, Businessman) "I think that the plastic packaging is important here because it helps in carrying the food safely." (Respondent 16, M, 56 years, Businessman) "I am in favour of the plastic packaging because it is easy to carry and dispose off as well. One does not have to wash the utensils as they are for one time use." (Respondent 7, F, 57 years, Housewife)
Impact on health	"Whenever we put hot food in plastic vessels, the plastic melts and gets mixed in the food and then we eat it. Hence, I don't like the plastic packaging used for food delivery." (Respondent 11, F, 58 years, Housewife) "I don't like the plastic packaging in which food is delivered because it negatively impacts the health. I want these food delivery systems to use biodegradable material for packaging." (Respondent 8, F, 60 years, Housewife) "While ordering food we don't have much choice but I always ask the restaurant to not send cutlery as that is also made of plastic which is bad for health. Eating food in steel vessels is the best choice." (Respondent 4, F, 59 years, Teacher)

Table 6. THEME 6- Cooking choice- Pressure cookers vs open pans

Sub-themes	Quotes
Taste preference	"Cooking food in pressure cookers makes the food mushy and I think it also causes loss of nutrients." (Respondent 13, F, 62 years, Teacher) "I prefer cooking food like rice in open pans because the taste and texture is much better." (Respondent 18, F, 59 years, Housewife) "I cook vegetables and rice in open pan because they don't get soggy and the taste is better." (Respondent 8, F, 60 years, Housewife)

Table 6 contd...

Sub-themes	Quotes
Time and energy saving	"Cooking food in a pressure cooker saves a lot of gas so it is a very economical choice." (Respondent 12, M, 63 years, Retired) "I prefer making food in a pressure cooker because that saves time as well as gas." (Respondent 10, F, 57 years, Teacher) "I prefer pressure cookers because I don't have a lot of time as I have a hectic work schedule. Cooking in pressure cookers takes lesser time compared to open pan cooking." (Respondent 17, F, 59 years, Govt. Job)

DISCUSSION

The findings reveal a mix of traditional values and practical considerations driving sustainable practices among individuals aged 50 and above in Jaipur. Many participants favoured sustainable options such as local produce, personal grocery bags, and food waste management techniques, often prioritizing health and cost over environmental considerations. This suggests that while sustainable practices are prevalent, there is limited understanding of the broader environmental impact, such as carbon footprint reduction. For instance, while some participants acknowledged the potential environmental benefits of purchasing locally grown produce, others expressed uncertainty about its actual impact, highlighting a gap in knowledge. Bridging this gap is essential, as higher levels of knowledge have been associated with more environmentally conscious decision-making, leading to choices that contribute to a lower overall environmental footprint (Hartmann et al., 2021).

Participants' reliance on cloth bags and preference for local produce reflects a traditional, sustainable approach. However, the gap in environmental awareness, particularly regarding the ecological benefits of local consumption and packaging waste, highlights the need for education initiatives targeting older populations. For example, while some participants raised concerns about the health risks of plastic packaging in food delivery, others found it convenient and necessary. This contrast highlights the need for better awareness regarding both the potential health implications of plastic and the benefits of biodegradable alternatives. Research shows that consumers who consider packaging sustainability often prioritize recyclability and biodegradability while overlooking broader environmental factors such as production and transportation impacts (Herbes et al., 2018). However, the absence of discussions on recyclability among participants in this study suggests an even greater gap in awareness, underscoring the need for targeted education on the comprehensive environmental impact of packaging choices. Well-designed initiatives can help bridge this gap by emphasizing the broader environmental significance of their everyday choices. Awareness campaigns tailored to older adults can highlight how their habits contribute to sustainability beyond personal benefits like cost savings and health. Practical interventions, such as community workshops, guided shopping experiences, and media outreach, can reinforce sustainable behaviours while introducing new strategies for minimizing environmental impact.

The diversity in cooking practices also suggests a balance between efficiency and sensory qualities. While pressure cookers are valued for energy savings, open-pan cooking remains popular for flavour. Educating this demographic on energy-efficient cooking methods could further promote sustainability. Additionally, offering incentives like discounts on locally sourced food products could encourage greater engagement in sustainable practices. Partnering with local markets and retailers to highlight sustainable product choices through clear labelling and informational materials may further enhance awareness. Interestingly, some participants reported actively repurposing leftover food into new meals, while others avoided leftovers entirely due to concerns about freshness. These differing perspectives suggest an opportunity to promote awareness about safe storage methods and innovative ways to reduce food wastage without compromising taste and nutrition. Since food handling skills, knowledge, and access to proper infrastructure significantly influence leftover food waste behaviours, interventions that focus on improving these aspects could help encourage sustainable food management practices at home (Aloysius et al., 2023). Emphasizing the cost-saving advantages of minimizing food waste could also drive behavioural changes among older individuals.

The integration of information and communication technologies (ICT) has the potential to drive positive change by enhancing knowledge dissemination, accessibility, and adoption of sustainable practices. While direct evidence on its impact in promoting sustainable nutrition among the elderly in India remains limited, research has demonstrated its effectiveness in enhancing sustainable agricultural practices among farmers (Niranjan et al., 2023). This suggests that similar digital interventions could serve as a potential strategy to foster awareness and adoption of sustainable nutrition practices among the elderly. Online platforms, including interactive mobile applications and virtual discussion forums, can be effective tools for engaging older adults in sustainability conversations. Customized digital content, such as instructional videos and expert-led webinars, can offer accessible learning opportunities tailored to their needs. Promoting digital literacy programs may further empower them to utilize ICT for informed and sustainable decision-making.

Integrating sustainability topics into social and cultural gatherings may encourage peer-driven learning, making sustainable practices more accessible and widely adopted. Social media could help consumers connect with farmers and agribusinesses, allowing them to make informed choices, access sustainably produced food, and support local and ethical food systems (Nain, 2023). By focusing on education and engagement, these initiatives can strengthen long-term commitment to environmentally conscious food choices. Future research could examine how community-driven sustainability programs influence behavioural changes among older adults. Furthermore, collaboration between policymakers and organizations could lead to the development of tailored

sustainability programs that align with senior citizens' lifestyles and preferences. Enhancing these initiatives can foster a more inclusive and effective approach to promoting sustainable nutrition among aging populations.

CONCLUSION

This study demonstrates that individuals in late adulthood in Jaipur engage in sustainable dietary practices mainly for personal health and economic reasons, with limited awareness of their broader environmental impact. While many participants practiced sustainability through locally sourced foods and waste reduction, these behaviours were often driven by tradition rather than an understanding of sustainability principles. This gap highlights the need for targeted educational programs to improve awareness of how food choices affect the environment. The findings suggest that policies and community initiatives should focus on integrating sustainability education into nutrition programs, emphasizing both personal and environmental benefits. Encouraging informed decision-making through awareness campaigns and community-based interventions can help older adults adopt more intentional sustainable practices. Future research should explore effective strategies for enhancing knowledge and promoting sustainable behaviours among this demographic to ensure long-term benefits for both health and the environment.

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Research Article

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Perceptual Analysis of Diverse Perspectives and Desired Proficiencies in 21st Century Skills among College Going Students

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HIGHLIGHTS

- Consistent familiarity with the term '21st century skills' among students, with no significant differences based on gender, course section, or course year was observed.
- Male students favoured student organizations and clubs for developing 21st century skills, whereas female students emphasize public speaking competitions and multimedia projects as more effective.
- A substantial proportion of college students perceive 21st-century skills as essential for enhancing their future readiness.

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Informed consent of the participants

ABSTRACT

In the dynamic post-secondary learning environment, understanding the multifaceted perspectives and sought-after competencies in 21st-century skills among college students is paramount. The ascendancy of 21st-century skills, encompassing learning and innovation skills, information and media literacy, as well as life and career skills, has become pronounced due to the widespread adoption of online education, driven by recent global circumstances. The present study undertakes a perception analysis of 21st-century skills among undergraduates enrolled in traditional courses at Banaras Hindu University (BHU), Varanasi from 2023-2024. Sample size of 325 participants was surveyed through a self-structured tool. The results revealed consistent familiarity with the term "21st-century skills" among students, regardless of gender, course section, or other demographic factors. There was insufficient evidence of an association between familiarity with the term '21st-century skills' and related factors. Students did not vary notably in their assessment of the importance of these skills across course sections. About abilities like critical thinking, creativity, and leadership, there were notable differences in perceptions.

INTRODUCTION

Rapid advancements in technology, society, and science are reshaping economies, businesses, and daily life. To thrive in this dynamic landscape, graduates must develop essential 21st-century skills such as continuous learning, innovation, self-improvement, data literacy, and complex problem-solving (Kocak & Goksu, 2020). The evolving needs of entrepreneurship can be met through a comprehensive approach that combines high-quality small business and life skills training with relevant technical education, financial support, and the cultivation of adaptable and future-ready competencies (Lekang et al., 2016; Lekang et al., 2017; Nain et al., 2019). 21st century skills encompass the necessary proficiencies for success in modern work, education, and commerce, surpassing traditional literacy, numeracy, and technical abilities (Geisinger, 2016) and the imperative arises for individuals to either collaborate with emerging technologies or undertake responsibilities inherently resistant to automation, underscoring the intrinsic interplay between human agency and technological advancement. A state of well-being and mindfulness requires a shift in thinking patterns, self-regulation, and confidence, along with changes in actions, ultimately leading to

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empowerment (Priyanka et al., 2019). Skills pertinent to the 21st-century embody the attributes that prepare individuals, particularly graduates, to function as conscientious citizens and proficient professionals in today's information society (Murat & Cam, 2021). This comprehensive description of skills considers the variety of attitudes, levels of knowledge, and proficiency that graduates need to exhibit to demonstrate specific types of expertise (Chehimi & Alameddine, 2022). As the most dynamic and essential part of society, students play a pivotal role in shaping the future, as their growth and development directly influence the progress and prosperity of a community or nation (Meinam et al., 2023). A fundamental shift in the paradigm of education is required to support students' learning of 21st-century abilities. Furthermore, Nieveen & Plomp (2018) noted that coordinated efforts are necessary for the effective acquisition of these skills at the classroom, school, and systemic levels. Assessing needs, providing hands-on training, experiential learning, and mentorship, along with social media exposure, effectively cultivates adaptive growth among students (Sanjeev et al., 2021 & Ray et al., 2022). The corpus of academic literature divides 21st-century abilities into various competencies that fall into three primary categories; Acquiring knowledge and innovative skills (creativity, critical thinking, problem-solving, communication, collaboration), Media literacy skills and Life and career skills including leadership, productivity and accountability, social skills, self-management, flexibility and adaptability (Häkkinen et al., 2016). The critical importance of the 21st century skill set is widely acknowledged by industry leaders and educational policymakers, despite the cultural variability and diversity in academic descriptions of these skills within scholarly sources (Kotsiou et al., 2022). These skills have been identified as crucial factors for individuals to succeed in their careers and ensure advancement (Ghafar, 2020). This research study aimed to explore the perceptions of college-going students regarding 21st-century skills and investigate their preferences regarding the development of 21st-century skills.

METHODOLOGY

A descriptive research design was used to assess college-going students' perceptions and preferences regarding various 21st century skills. Stratified random sampling was opted for the present study. The survey was administered in the year 2024 to a cohort of 325 undergraduate students enrolled in traditional undergraduate courses across the first, second, and third years at Banaras Hindu University in Varanasi, Uttar Pradesh. Participants were selected from Science, Arts, Social Science, and Commerce disciplines, encompassing students from all academic years and including both male and female students, to ensure a diverse, representative, and inclusive sample that captures a broad range of perspectives and experiences. The voluntary nature of the survey entailed that participants were not incentivized for their engagement, and they were requested to respond to the inquiries based on their overall perceptions of 21st-century skills. A reliable and valid self-structured questionnaire was developed as the primary data collection tool to gather comprehensive insights. Students assessed nine of the twenty perception items using a five-point scale as strongly agree (5), agree (4), neutral (3), disagree (2) and strongly disagree (1). The remaining perception items were structured as multiple-response checkbox questions to capture a broader range of students' perspectives on various 21st-century skills. The collected data were analyzed using descriptive statistics, including percentage and mean rank, to summarize students' perceptions of 21st-century skills. To assess variations among groups, the Kruskal-Wallis H-test was conducted. In cases where significant differences were identified, Dunn's test with Bonferroni correction was applied as a post hoc analysis to determine specific group-wise distinctions. The results were systematically presented in tables for clarity and structured interpretation.

RESULTS

By analyzing data across diverse student demographics, the research seeks to uncover how students perceive the relevance and need of these skills. The findings of this study are as follows: A diverse group of respondents participated in the study, including students spanning various undergraduate courses, and course years. Out of the 325 students surveyed, the gender distribution leans towards 41 per cent male and 59 per cent female. Additionally, the distribution of undergraduate students by year of study comprised 34 per cent first-year, 58 per cent second-year, and 8 per cent third-year students, offering insights from different academic stages.

Association of "21st-century skills" term familiarity of the students with another factors

The study revealed that familiarity with the term "21st-century skills" did not differ significantly based on gender, course section, course year, and type of school. Male and female students demonstrated similar levels of awareness, indicating that gender did not play a crucial role in shaping familiarity. Likewise, respondents across different academic years showed comparable familiarity. However, a significant variation was observed among students from different course sections, implying that academic discipline influenced awareness levels.

To foster creative thinking, a crucial 21st century skill, university educators should encourage creative inquiry through collaborative learning and open-ended assignments. This approach supports the integration of innovative teaching strategies (Katz-

Table 1. Perceived skills by students as 21st century skills

Skills	Mean rank		H-statistic	p-value
	Male	Female		
Critical thinking	182	146	6.24	<0.001
Creativity	153	168	5.389	<0.001
Collaboration	168	155	13.04	0.156
Communication	169	153	13.94	0.031
Digital literacy	150	165	11.20	0.031
Legal literacy	178	150	6.31	0.50
Flexibility	165	168	12.15	0.456
Leadership	182	147	21.80	<0.001
Initiative and self-direction	156	160	8.76	0.692
Social interaction	157	163	5.08	0.572
Problem solving	159	162	5.04	0.570
Perseverance	160	162	6.22	0.850
Conflict resolution	160	160	5.04	0.993

Buonincontro et al., 2020). The results of the Kruskal-Wallis test as shown in Table 1, gender disparities were evident in the perception of several key 21st-century skills, particularly in areas such as critical thinking, creativity, communication, digital literacy, and leadership. However, no significant differences were observed between male and female students regarding collaboration, and legal literacy, flexibility, initiative, social interaction, problem solving, perseverance, and conflict resolution.

Students' critical thinking skills enhance their ability to employ writing strategies during source-based writing tasks. Furthermore, gender plays a crucial role in shaping students' critical thinking abilities (Zhao et al., 2024). A thorough understanding of the differences in perceived necessity of 21st-century skills across various course sections is essential for the development of effective educational programs. Notable disparities exist among course sections regarding students' perceptions of the importance of several key skills. The Kruskal-Wallis test results indicate a statistically significant difference in familiarity among students from different course sections, suggesting that certain disciplines provide greater exposure to these skills than others, potentially due to variations in curriculum or instructional strategies. Specifically, significant differences were observed for critical thinking ($H=6.24$, $p<0.001$), creativity ($H=5.389$, $p<0.001$), leadership ($H=21.80$, $p<0.001$). Post-hoc Dunn's test with Bonferroni correction identified significant differences in leadership between social science and arts ($p=0.0206$) and arts and science ($p=0.0068$). Similarly, critical thinking showed significant differences between social science and arts ($p=0.0152$) and arts and science ($p=0.0094$). Creativity also varied significantly between social science and arts ($p=0.0185$) and arts and science ($p=0.0071$).

As shown in Table 2, both genders acknowledge the significance of various 21st-century skills; however, their emphasis differs across specific skill domains. Female students highlight the significance of collaboration, communication, and fostering a lifelong learning mindset more than male students. On the other hand, males are more inclined towards preparing for the future and enhancing critical thinking abilities. This gender-based divergence in priorities underscores the necessity for educational programs to cater to these varying perceptions, ensuring that all students develop a balanced set of essential skills for their future careers.

The data suggests that males perceive joining student organizations or clubs as a more effective activity for developing 21st-century skills, while females place greater importance on public speaking competitions and creating multimedia projects. Table 3 illustrates gender-based differences in students' preferred activities for developing 21st-century skills. Male students show a stronger inclination toward joining student organizations or clubs compared to female students. Meanwhile, female students place greater emphasis on public speaking competitions and multimedia projects than their male counterparts. Both genders equally recognize the value of internships and volunteering activities. These variations highlight the need for diverse educational opportunities that cater to students' unique skill development preferences. These differing perceptions highlight the need for a diverse range of activities in educational programs to cater to various student preferences, ensuring that all students have opportunities to engage in activities they believe aid in developing their skills.

Table 2. Respondents' distribution by perceived importance of 21st-century skills

Key Reasons	Female (%) n=192	Male (%) n=133
Preparing individuals for the future	58	92
Enhancing critical thinking abilities	62	75
Improving collaboration skills	79	65
Strengthening communication capabilities	84	65
Fostering innovativeness	67	63
Encouraging a lifelong learning mindset	76	57
Developing leadership competencies	65	65

Table 3. Respondents' perceptions regarding activities that aid in developing 21st century skills

Activities	Female (%) n=192	Male (%) n=133
Joining student organizations or clubs	59	77
Getting involved in volunteering activities	69	70
Participating in internship programs	52	52
Participating in public speaking competitions or debate clubs	68	63
Creating multimedia projects such as videos, podcasts, or blogs	67	59

DISCUSSION

The findings of this study provide valuable insights into the factors influencing students' familiarity with the term "21st-century skills". Notably, gender and course year do not appear to have a significant impact, suggesting that awareness of these skills is relatively consistent across different student demographics. The findings suggest that familiarity with various 21st century skills is widespread and not solely influenced by factors such as gender, course section, faculty, or academic year. A significant variation in the perceived need for various 21st century skills was observed across course sections, suggesting that certain disciplines prioritize these competencies through curriculum design, pedagogical strategies, or the integration of skill-based learning within academic programs. Global recognition underscores the necessity of teaching and evaluating complex competencies known as twenty-first-century skills. Amore uniform perception of the need for these skills across genders, implying that general educational strategies for these areas might be equally effective for all students. Differences in learning strategies are evident among higher education students, with variations in the depth of cognitive and metacognitive elaboration despite the use of similar terminology. Adaptability in learning strategies is influenced by multiple factors, particularly assessment activities, shaping students' approach to learning. Students with lower academic performance demonstrate challenges in organization and possess limited knowledge of effective learning strategies (García-Pérez et al., 2021). No significant gender differences were found for collaboration, communication, digital literacy, legal literacy, financial literacy, flexibility, and social interaction across various course sections. In today's competitive job market, strong professional communication skills are essential

for securing employment in both the public and private sectors and students, as future job seekers, favored short and intensive communication skills training programs conducted on college or university campuses (Sikdar and Prakash, 2025). A previous study mentioned digital knowledge, digital attitude, and digital competency as three overarching dimensions, with the latter encompassing several sub-dimensions (Chandra et al., 2024). Critical thinking, a key component of these skills, is essential for problem-solving and decision-making. Low critical thinking has been linked to "risk-taking" and "lost in translation" profiles among undergraduates, indicating potential difficulties in judgment and problem-solving. In contrast, strong critical thinking enhances stress management, improves academic performance, and reduces procrastination (Hen & Goroshit, 2018). For instance, studies have shown that women often emphasize leadership and initiative due to their unique career challenges and societal expectations. This is particularly important in educational contexts where empowering female students through leadership opportunities can have a profound impact on their career trajectories (Smith, 2023). Additionally, the universal importance of critical thinking and creativity is recognized across educational research, though the ways in which these skills are developed and prioritized can differ based on gender (Lim et al., 2020). Addressing these differences through customized educational programs can help in closing the gender gap and ensuring that all students are equally prepared for the demands of the 21st century (Anderson et al., 2022). The analysis suggests a need for gender-sensitive educational strategies that effectively address the diverse needs of students. By recognizing and addressing the significant gender differences in the perceived need for critical thinking, creativity, leadership, and initiative and self-direction, educational programs can be better tailored to prepare all students for the challenges of the 21st century (Lim et al., 2020). This approach not only enhances the overall effectiveness of skill development initiatives but also promotes a more equitable and inclusive educational environment (Anderson et al., 2022).

CONCLUSION

The study has illuminated the perceptions and preferences of higher education students regarding 21st century skills. Addressing the significant disparities in the perceived importance of critical thinking, creativity, leadership, and self-directed learning is essential for crafting educational programs that adequately equip students for 21st century demands. Such an approach not only strengthens the impact of skill development initiatives but also fosters a more inclusive and equitable learning environment. These insights underscore the necessity for educational institutions to adapt curricula and teaching strategies to better align with students' evolving needs and expectations. While the research provides valuable guidance for enhancing educational practices, it is also limited by its sample size and scope, suggesting the need for further studies to explore these dynamics in diverse contexts.

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Research Tool

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A Tool to Measure Farmers' Training Needs in Drone-based Technologies

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HIGHLIGHTS

- The 34 out of 53 training need statements met statistical criteria, ensuring relevance for agricultural drone technology.
- Item-total correlation analysis retained items with strong associations ($r \geq 0.70$), improving scale reliability.
- Cronbach's Alpha for all constructs exceeded 0.80, confirming high internal consistency and construct reliability.
- The highest t-values indicated the importance of online courses, weather conditions, and irrigation management for drone adoption.

ARTICLE INFO

Keywords: Drone technology, Training need, Scale development, Reliability, Validity.

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ABSTRACT

A measurement tool has been developed to determine the training needs of farmers in the usage of drone-based technologies towards the sustainable agriculture. A list of 84 statements was collected and refined based on Edward's 14 principles and 53 statements were retained for administering to farmers from non-sampling areas for further analysis. The statements were categorised under four constructs viz. Training Need for Drone Technical Knowledge (DTK), Platform for Learning Drone Technology (PLT), Practical Applications in Agriculture (TNP), Regulations, Permits, and Safety Protocols (TRS). Finally, the t-value for each statement was calculated and found that 34 statements had a t-value greater than 1.75. The 34 statements were further computed by item-total correlation analysis. The four items were found less than the threshold level of 0.30 implies a very weak association, and were removed to improve scale reliability. The final 30 statements were retained for the final scale and administered for reliability and validity testing. The Cronbach's alpha coefficient validated that all four constructs demonstrated high reliability ($\alpha > 0.80$), signifying that the items within each construct were strongly correlated and confirmed the internal consistency of the developed scale. The content validity of the scale was established with the judgement of the experts.

INTRODUCTION

As India progresses towards Agriculture 5.0, defined by automation, data-centric farming, and intelligent technologies, drones are anticipated to be instrumental in the modernisation of the agricultural sector. Drones provide enhanced spatial and temporal resolutions compared to conventional techniques like manual scouting or satellite imaging, enabling farmers to monitor crop health, identify diseases, and evaluate soil conditions with remarkable precision (Sengupta, 2023; Martel et al., 2021). Drones equipped with multispectral sensors can capture high-resolution images to identify variations in chlorophyll content, water stress, and nutrient deficiencies, allowing farmers to rectify issues before they worsen (Moses-Gonzales et al., 2021; Yue et al., 2018). This capability mitigates crop losses and diminishes dependence on chemical treatments. Drones outfitted with soil moisture sensors and thermal cameras offer critical insights into soil and plant hydration levels, facilitating accurate irrigation methods (Guebsi et al., 2024; Zhang et al., 2019). Despitetheir transformative potential, drones have numerous adoption challenges. The deficiency of technical

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proficiency among small-scale farmers presents a major challenge (Rejeb et al., 2022; Lahiri et al., 2024). Ethical and privacy issues must also be considered. Farmers must ensure that drone operations adhere to the privacy of properties nearby and conform to data protection regulations (Guebsi et al., 2024). The environmental consequences of frequent drone usage, including disturbances to wildlife, necessitate careful consideration (Mahroof et al., 2021). The availability of trained drone pilots might be another potential hindrance to the adoption of drone-based applications in the lo. This research article aims to address this gap by introducing a scale designed to assess the training requirements of farmers regarding the utilisation of drone-based technologies in agriculture. Consequently, the present study enhances the existing body of knowledge by offering a thorough and context-specific measurement instrument that can direct future research and inform evidence-based policies and programs. This research aims to enhance the understanding of farmers' training needs for the proper application of drone-based technologies in agriculture, thereby contributing to sustainable agricultural practices and development.

METHODOLOGY

The present study follows the summated rating method, as Likert suggested (1932), to develop a training needs assessment scale for farmers' usage of drone-based technologies in agriculture. The Likert scale measures individual differences among respondents regarding their possession or opinion on a specific attribute or aspect (Ramya et al., 2019). The methodologies employed by Kumar et al., (2016); Gupta et al., (2022) & Vijayan et al., (2022) were followed according to.

The statements related to different dimensions of training needs in drone-based technologies were collected from a comprehensive literature review and expert consultations with specialists in agricultural extension education, precision agriculture, and digital technologies. A tentative list of 84 statements was drafted to ensure applicability and these statements were then edited and refined based on 14 criteria suggested by Edwards (1957) to ensure clarity, relevance, and validity. After expert evaluation, irrelevant or redundant statements were removed, leading to a final selection of 53 statements for the training needs scale.

Finally, the statements were administered to 50 farmers from a non-sampling area and the responses were collected using a five-point Likert scale, where farmers could indicate their level of agreement or disagreement with each statement from strongly agree to strongly disagree. To ensure item validity, a t-test analysis was conducted for each statement. The computation of a t-value for each statement to assess its ability to differentiate between farmers with high and low training needs. The t-value serves as a measure of differentiation, identifying statements that effectively distinguish between farmers who require more training and those with existing knowledge. Statements with t-values significant at the 5% level ($p < 0.05$) were selected for the final training needs scale.

The current study involved Cronbach's Alpha to assess reliability using the Statistical Package for Social Sciences (SPSS 26.0). Different authors have varying opinions regarding the acceptable alpha value for internal consistency. Di-Iorio (2005) advocates for a value close to 1.0, while Streiner & Norman (2008) propose that values between 0.70 and 0.90 are adequate. The construction and content validity of the scale aimed to establish the instrument's validity. Minor modifications to the wording and structure of the instrument were implemented based on the recommendations of the panel of experts selected in this study. Furthermore, validity is typically a matter of degree rather than an absolute characteristic, and validation is an ongoing process (Nunnally & Bernstein, 1994).

RESULTS

Selection of training needs statements for the final scale

Statements with t-values ≥ 1.75 and p-values ≤ 0.05 demonstrate strong differentiation and statistical significance. After computing the "t" value for all the items, 34 statements showing a significant difference between low and high groups with t-values $\geq$ 1.75 and at a 5% level of significance ($p<0.05$) were selected. It has been concluded that 19 items failed to show strong statistical significance, with low t-values (<1.75) and high p-values ($p>0.05$), indicating that they do not significantly differentiate between groups for the measurement of training needs demanded to be measured. It has been decided these are to be removed from the scale. Statements with strong t-values and low p-values should be retained for scale development (Table 1). The range of t-values for the selected items ranged from a maximum of 8.66 to a minimum of 2.53. In this way, 34 out of 53 statements were retained for further analysis.

Item-total correlations were computed for 34 of the items. This practice is a commonly accepted procedure when developing a scale (Churchill, 1979). The Item-Total Correlation (r-value) is a measure that evaluates how well each item correlates with the total scale score, providing an important analysis of the consistency and reliability of individual items within a given scale. A higher item-total correlation (≥ 0.70) indicates a strong relationship between an item and the overall construct being measured, suggesting that the item is a meaningful contributor to the scale. Items with a varied range of correlation (0.30-0.69) also align with the construct and are still acceptable. However, a lower item-total correlation (< 0.30) implies a very weak association, which may indicate redundancy, irrelevance, or the need for removal to improve scale reliability. Following this, items such as 'understanding different drone types and their suitability' (0.239), 'the impact of wind speed and altitude on drone stability' (0.191), Collaborative research initiatives between universities and farmers (0.078) and Ethical considerations in drone-based farm monitoring (0.226) exhibited weak correlations (<0.30), suggesting they do not contribute meaningfully to the scale. To purify the scale, these items were eliminated. This procedure resulted in 30 items, out of the original 34, being retained.

Validity and reliability analysis

Content validity was employed to assess the scale's validity. Content validity involves a systematic analysis of the test content to ensure it represents a comprehensive sample of the behavioural domain being evaluated. In this study, we established content validity by gathering statements from pertinent literature and obtaining the opinions of experts in the field of extension, who possess extensive experience in this area. The methodology of

Table 1. Item analysis and item co-relational analysis of statements

S.No.	Statements	t-value	p-value	r- value
	Training Need for Drone Technical Knowledge			
1.	Basic drone navigation and control techniques.	5.087	0.000	0.716
2.	Drone software for flight planning and execution.	5.692	0.000	0.648
3.	Drone maintenance and troubleshooting common technical issues.	5.692	0.000	0.704
4.	Understanding battery management and maximising flight time.	5.159	0.000	0.673
5.	Integration of sensors with drones for data collection.	5.382	0.000	0.658
6.	Weather conditions and their impact on drone operation.	7.890	0.000	0.704
7.	Understanding of GPS technology and its role in drone navigation.	5.367	0.000	0.573
8.	Understanding different drone types and their suitability.	3.704	0.001	0.239
9.	Impact of wind speed and altitude on drone stability.	2.307	0.025	0.191
	Platform for Learning Drone Technology			
10.	Agricultural extension services for learning drone technology.	4.717	0.000	0.753
11.	Online courses or training modules on drone technology.	8.664	0.000	0.622
12.	Hands-on workshops or field demonstrations for drone usage.	6.162	0.000	0.552
13.	Learning platforms for sharing drone knowledge and experiences.	4.610	0.000	0.711
14.	Government or private-sector-sponsored training initiatives.	6.284	0.000	0.659
15.	Digital resources (videos, webinars) for self-paced learning.	4.128	0.000	0.653
16.	Collaborative research initiatives between universities and farmers.	4.245	0.000	0.078
	Training Need for Practical Applications in Agriculture			
17.	Crop health assessment (disease detection through imaging).	6.308	0.000	0.681
18.	Crop mapping and accurate field models using drone data.	4.454	0.000	0.629
19.	Irrigation management and optimising water distribution.	6.614	0.000	0.635
20.	Precise pesticide/fertiliser application.	6.079	0.000	0.736
21.	Crop damage evaluation.	6.169	0.000	0.683
22.	Soil health monitoring and nutrient deficiency detection.	4.301	0.000	0.781
23.	Planting and seeding operations.	5.683	0.000	0.671
24.	Integrate drone data for yield estimation and forecasting.	5.002	0.000	0.610
25.	Livestock monitoring (tracking movement, health, and behaviour).	6.340	0.000	0.684
26.	Monitoring and managing crop stress.	5.609	0.000	0.712
	Training Needs for Regulations, Permits, and Safety Protocols			
27.	Local drone flying regulations specific to agriculture.	4.532	0.000	0.663
28.	Permits required for operating drones in agricultural zones.	5.159	0.000	0.677
29.	Safety protocols, including pre-flight and post-flight safety checks.	6.465	0.000	0.616
30.	Understanding airspace restrictions and drone no-fly zones.	4.390	0.000	0.834
31.	Privacy and data protection laws.	4.462	0.000	0.808
32.	Emergency procedures and drone recovery methods.	5.754	0.000	0.745
33.	Obtaining and renewing licenses or certifications for drone operation.	6.340	0.000	0.719
34.	Ethical considerations in drone-based farm monitoring.	2.527	0.015	0.226

content validity testing corresponds with the suggestions of Shitu et al., (2018) and has also been utilised by others (Gupta et al., 2022; Chandra et al., 2024; Tripathy et al., 2024) to evaluate the validity of their research instrument.

Reliability, as articulated by Ray & Mondal (2011), refers to the degree of consistency observed across multiple measurements of a specific variable. In this study, we employed the Cronbach alpha coefficient, a measure of internal consistency, to evaluate the reliability of the measurement instrument. The procedure entailed analysing the responses from the study participants utilising SPSS statistical software. Cronbach's alpha is a coefficient that measures the degree of correlation among items within a scale. A higher alpha value indicates increased reliability. A construct is reliable if the Cronbach Alpha (α) value is greater than 0.70 and, in some cases, a Cronbach coefficient of 0.6 and more is also considered good enough to prove the reliability of the measuring instrument. Construct reliability was assessed using Cronbach's Alpha by using the SPSS tool. The results revealed that the Training Need for Drone Technical Knowledge (DTK) scale with eight items (α=0.856) and the Platform for Learning Drone Technology (PLT) scale with six items (α=0.823) were found reliable. Similarly, the Training Need for Practical Applications in Agriculture (TNP) scale with ten items (α=0.899) and the Training Needs for Regulations, Permits, and Safety Protocols (TRS) scale with seven items (α=0.898) were also found reliable. Reliability results are summarised in Table 2.

DISCUSSION

The scale development process involved a detailed selection and refinement of items that ensured the validity and reliability of the measurement tool. The selection of training need statements was based on statistical criteria, wherein items with t-values $\geq$ 1.75 and p-values $\leq$ 0.05 were deemed statistically significant and

Table 2. Reliability Statistics

Constructs	No. of Items	Cronbach Alpha (α)
Training Need for Drone Technical Knowledge (DTK) Basic drone navigation and control techniques. Drone software for flight planning and execution. Drone maintenance and troubleshooting common technical issues. Understanding battery management and maximizing flight time. Integration of sensors with drones for data collection. Weather conditions and their impact on drone operation. Understanding of GPS technology and its role in drone navigation.	07	0.856
Platform for Learning Drone Technology (PLT) Agricultural extension services for learning drone technology. Online courses or training modules on drone technology. Hands-on workshops or field demonstrations for drone usage. Learning platforms for sharing drone knowledge and experiences. Government or private-sector-sponsored training initiatives. Digital resources (videos, webinars) for self-paced learning.	06	0.823
Training Need for Practical Applications in Agriculture (TNP) Crop health assessment (disease detection through imaging). Crop mapping and accurate field models using drone data. Irrigation management and optimizing water distribution. Precise pesticide/fertilizer application. Crop damage evaluation. Soil health monitoring and nutrient deficiency detection. Planting and seeding operations. Integrate drone data for yield estimation and forecasting. Livestock monitoring (tracking movement, health, and behavior). Monitoring and managing crop stress.	10	0.899
Training Needs for Regulations, Permits, and Safety Protocols (TRS) Local drone flying regulations specific to agriculture. Permits required for operating drones in agricultural zones. Safety protocols, including pre-flight and post-flight safety checks. Understanding airspace restrictions and drone no-fly zones. Privacy and data protection laws. Emergency procedures and drone recovery methods. Obtaining and renewing licenses or certifications for drone operation.	07	0.898

exhibited robust differentiation between low and high training need groups. Of the 53 initial statements, 34 satisfied the criteria and were retained for further analysis, whereas 19 items were removed due to low t-values (<1.75) and high p-values (>0.05). The results indicate that the retained items are highly relevant for evaluating training requirements in agricultural drone technology, while the excluded items failed to distinguish between training needs meaningfully, thus contributing minimal value to the scale. The t-values for the selected statements ranged from 2.53 to 8.66, with higher t-values signifying greater statistical differentiation between groups. The highest t-value (8.66) among the selected items was found for "online courses or training modules on drone technology," highlighting the increasing inclination towards digital and remote learning platforms. Likewise, "weather conditions and their impact on drone operation" (t=7.89) and "irrigation management and optimising water distribution" (t=6.61) exhibited substantial significance, underscoring their importance for drone integration in agriculture. The 19 items exhibited inadequate differentiation, indicating that agricultural stakeholders may not regard these aspects as essential. The elimination of these items conforms to standard scale refinement procedures to improve the accuracy and relevance of the measurement.

After item selection, an item-total correlation analysis was performed to evaluate the strength of each item's association with the overall scale score. Items exhibiting high item-total correlations ($r \geq 0.70$) were retained, as they indicated strong consistency and significant contribution to the overall construct being assessed. Items showing moderate correlations ($0.30 \leq r < 0.70$) were retained, as they corresponded with the construct despite some variability in their contributions. Items exhibiting low item-total correlations ($r< 0.30$) were considered weakly associated and subsequently removed to improve scale reliability. Four items revealed weak correlations and were consequently excluded from the scale. Ethical implications of drone-assisted agricultural surveillance (r=0.226). These items exhibited insufficient alignment with the core construct and were probably not regarded as essential training needs by respondents. Their elimination led to a final scale of 30 items, guaranteeing the retention of only relevant and statistically reliable statements for additional validation. Content validity and reliability testing were conducted to evaluate the scale's effectiveness. Content validity

was established via expert evaluations and item selection grounded in literature. The methodology employed aligned with prior scale development studies (Shitu et al., 2018; Chandra et al., 2024; Tripathy et al., 2024; Gupta et al., 2022), thereby supporting the strength of the scale's construct validity. Reliability analysis was performed utilising Cronbach's Alpha, a recognised measurement for internal consistency (Ray & Mondal, 2011). The findings validated that all four constructs demonstrated high reliability ($\alpha >$ 0.80), signifying that the items within each construct were strongly correlated and assessed a unified training need dimension. The Training Need for Practical Applications in Agriculture (TNP) construct revealed the highest reliability (α = 0.899), signifying strong coherence among items evaluating the agricultural applications of drones. Likewise, the TRS construct (α = 0.898) showed substantial reliability, highlighting the significance of regulatory knowledge and compliance in the adoption of drones. Although DTK (α = 0.856) and PLT (α = 0.823) showed high reliability, their marginally lower coefficients indicate that these domains may include a wider spectrum of learning experiences and technical skills. All four constructs surpassed the widely recognised threshold of 0.70, validating their appropriateness for scale implementation.

CONCLUSION

The study effectively established a statistically validated and reliable scale for evaluating the training needs. The development of this training needs assessment scale provides a scientifically validated tool for measuring farmers' perceptions, attitudes, and requirements regarding drone-based technologies in agriculture. The final scale consists of 30 significant training need statements derived from thorough item selection, item-total correlation analysis, and reliability testing, categorised into four distinct constructs. The use of Likert's summated rating method and t-test validation ensures that the scale captures relevant and statistically significant training gaps. This structured approach will aid policymakers, extension professionals, and agricultural training institutions in designing targeted training programmes that enhance farmers' knowledge, skills, and adoption of drone-based technologies, ultimately leading to improved agricultural efficiency and sustainability.

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Research Note

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Analysis of Adoption Practices of SRI in Tribal Region of Sundargarh District in Odisha

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HIGHLIGHTS

- Extra care had to be taken in main field preparation in SRI than the conventional method.
- Poor adoption was noted for green manuring, vermicomposting, and applying the recommended dose of compost or farmyard manure.
- Further exposure is needed to understand the benefits, enabling respondents to adopt and continue the SRI rice cultivation method.

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ABSTRACT

The study was conducted in 2020 and data was collected randomly from ten Gram panchayats spread across five blocks of Sundargarh district of Odisha, the total farmers being 96 in the tribal area who had stopped using System of Rice Intensification (SRI) in paddy cultivation. It was found that in spite of all efforts and incentives the farmers were not developing enthusiasm to continue the method. Therefore, the goal of the present study was to assess the causes of discontinuance in SRI method of rice cultivars. It revealed that poor adoption of raising nursery beds at 80-100 cm height, putting seedlings in a thin metal sheet for transplanting, applying recommended dose of manure or vermicompost and green manuring, applying nitrogen in three splits, alternate drying and wetting of the main field, light irrigation during hair line cracks and applying minimum of four weeding at 10 days interval. Path analysis revealed that the socio-economic attribute education through housing pattern, annual income, extension contact, social participation, agricultural implements use significantly influenced adoption practices.

INTRODUCTION

Adopting a demand-driven strategy is crucial for the effectiveness of agricultural extension services, particularly in the ever-changing agricultural sector (Godara et al., 2024). The System of Rice Intensification (SRI) involves a package of practices aimed at increasing yield without relying on additional seeds, chemical fertilizers, or other external inputs (Agarwal et al., 2019). Key practices for nursery raising include using raised seedbeds (80-100 cm), well-decomposed manure, good drainage, seed treatment, and uniform seed broadcasting. Transplanting 8–12 day-old seedlings (1 per hill) at 25 x 25 cm spacing, maintaining field saturation, weeding with a conoweeder, and emphasizing organic nutrient management are essential steps (Kiran & Shenoy, 2010).

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However, SRI practices are labor-intensive and time-consuming. Challenges like inadequate labor skills and the lack of proper equipment for tasks such as leveling, weeding, and nursery management can impede the adoption of these practices (Krishna, 2016). Farmers often struggle with issues like increased weeds, labor shortages, unsuitability for heavy or saline soils, difficulties with markers, improper field leveling, lack of manure, and the need for timely and intensive weed management in nurseries (Biswas & Nath, 2013; Kiran & Shenoy, 2010; Singh & Varshney, 2010). Cono-weeders (58.21%) and nursery management (56.61%) are the primary obstacles to SRI cultivation. In Ranchi, Jharkhand, key challenges include lack of awareness, skilled labor shortages, and the difficulty of using cono-weeders (Agarwal & Kumar, 2017). Farmers often identify challenges such as maintaining water levels in fields, difficulties in mechanical weeding, unreliable irrigation sources, large area coverage with mechanical weeders, unpredictable rainfall, and insufficient organic fertilizers as major barriers to SRI adoption (Pal et al., 2019).

In Imphal, Manipur, a significant issue hindering SRI adoption is the lack of suitable row marker for transplanting (Salam et al., 2022). Farmers are motivated to adopt SRI due to lower cultivation costs, higher yields of grains and straw, access to subsidies, and reduced seed rates (Johnson et al., 2012). A Tobit study highlights that the number of training sessions attended and the availability of extension services significantly affect SRI adoption. A primary barrier to implementation is the lack of competent workers (Handral et al., 2017). To improve adoption nationwide, farmers need to adopt best practices and receive technical support through community-based nursery cultivation (Shanmugasundaram, 2015). Factors such as perceived behavioral control, training participation, and family assets are major determinants of adoption, according to a study using the Theory of Planned Behavior and the Technology Acceptance Model (Moore et al., 2024).

In Balaghat, Madhya Pradesh, research found that paddy production levels among SRI farmers were strongly correlated with landholding, social participation, media exposure, extension involvement, knowledge of SRI technology, and economic motivation (Rahangdale et al., 2011). The present study found that while farmers participated in demonstrations, they did not continue SRI practices despite positive harvest outcomes. This suggests that there are underlying constraints preventing long-term adoption, which was the focus of the research–understanding the deficiencies causing the discontinuance of SRI cultivation in the study area.

METHODOLOGY

In 2020, the research was conducted in the tribal district of Sundargarh. Among the list of blocks, Sundargarh Sadar, Subdega, Balisankara, Bargaon and Nuagaon were randomly selected for the study. A sample of 96 rice growers by using SRI technology from 10 Gram Panchayats of 5 these selected blocks was selected by simple random sampling as the respondents for the study. Nursery raising, main field preparation, transplanting, nutrient, water, and weed management practices were chosen as the statements of adoption scale. The data collected on a scale point of fully, partially, and not adopted over the framed statement were analyzed with a score of 3, 2, and 1 respectively. So 3-point scale was adopted. Statistical tools such as mean score, gap percentage, and path analysis were employed to reveal the results.

Mean is the average which is calculated by using the following formula.

$$\text{Mean } (\bar{X}) = \frac{\Sigma f x_i}{N}$$

Where, $\bar{X}$ = The symbol used for mean, Σ = Summation, Xi = Values of i^{th} item, N = Total number of respondents

$$\text{Gap } (\%) = \frac{\text{Total Score-Obtained Score}}{\text{Total Score}} \times 100$$

RESULTS

Proper care should be taken in the preparation of a good nursery bed. The seedling must be healthy as 8-10 days old seedlings are to be transplanted. Well-pulverized seed beds, application of well decomposed manure, seed germination, and showing at shallow depths are some of the important practices in raising nursery beds. However, the raised beds help improve water drainage, prevent soil compaction, and allow for better root growth by ensuring the seedlings have access to well-drained soil but poor adoption was observed (Table 1) on raising seed beds at 80-100 cm height. Poor adoption rates were observed on alternate drying and wetting of the main field and light irrigation during hairline cracks. This practice is crucial in SRI because it helps in regulating water usage and prevents the field from becoming either too dry or too waterlogged, both of which could hinder plant growth. It is also recommended to keep 2-3 cm of standing water after flowering as well as draining water after 20 days of flowering to harvest well-matured and bold grains. However, the adoption of these practices was not satisfactory. The respondents therefore need to be further exposed to extension approaches for a clear understanding about the benefits of all these practices. Special management practices are to be adopted in the SRI method. Young seedlings of 8-12 days are advised in transplanting. The seedlings should not be damaged either during uprooting or transplanting in the main field alongwith keeping the seeds intact. Only one seedling need to be transplanted at shallow depth and erect per hill at a spacing of 25 x 25 cms. Only organic manure is recommended in the SRI method of rice cultivation. However, the State Department of Agriculture has advised applying half dose of recommended fertilizers in rice along with organic manure due to unavailability. Green manuring and vermicomposting are also recommended to supplement farm yard manure. Poor adoption was observed on the adoption of green manuring and vermi compost application and 4 weeding at 10 days interval.4 weeding at 10 days interval practice of conducting a minimum of four weeding at 10-day intervals ensure that the paddy plants are not deprived of these essential resources. Transplanting seedlings using a thin metal sheet serves as a technique to avoid root damage during the transplantation process but poor adoption rate was observed in putting seedlings in a thin meta sheet for transplanting The metal sheet holds the seedlings in place, ensuring they are planted in a straight line at the correct spacing and depth. This practice helps in maintaining uniformity in seedling placement,

Table 1. Analysis of Adoption of practices

Sl.No	Practice	Mean score	Poor/High
i.	Raising seed bed at 80-100 cms height	1.51	Poor
ii.	Light irrigation during hairline cracks	1.52	Poor
iii.	Putting seedlings in a thin meta sheet for transplanting	1.68	Poor
iv.	Adopting green manuring practices	1.69	Poor
v.	Producing and applying vermicompost	1.78	Poor
vi.	Minimum of 4 weeding at 10 days interval	1.97	Poor
vii.	Alternate drying and wetting of the main field	1.98	Poor
viii.	Maintaining water soil saturation	3.00	High
ix.	Keeping drainage channel around sub-plotting	3.00	High
x.	Not keeping standing water during transplanting	2.94	High
xi.	Irrigating one day before weeding	2.91	High
xii.	Using cono/mandvaweeder for weeding	2.88	High
xiii.	Applying potash in two splits	2.86	High
xiv.	Planting seedlings erect at shallow depth	2.95	High
xv.	Not keeping standing water during transplanting	2.94	High
xvi.	Irrigating one day before weeding	2.91	High
xvii.	Using cono/mandvaweeder for weeding	2.88	High
xviii.	Raising seedling in 100 sq meter area for transplanting 1.0 ha land	2.52	High

Table 2. Path analysis of socio-economic attributes influencing adoption

S.No.	Attribute	Total effect	Total direct effect	Total indirect reflect	Substantial effect I	Substantial effect II	Substantial effect III
X_1	Age	0.128	0.087	0.041	$0.173x_9$	$-0.123x_{11}$	$-0.034x_{10}$
X_2	Education	0.143	-0.184	0.327	$-0.156x_{12}$	$0.086x_1$	$-0.042x_4$
X_3	Caste	0.346	0.136	0.210	$-0.144x_{13}$	$0.105x_6$	$-0.042x_{11}$
X_4	Housing Pattern	0.421	0.197	0.224	$-0.206x_2$	$0.167x_9$	$0.088x_{13}$
X_5	Holding size	0.251	0.084	0.167	$-0.223x_5$	$0.172x_8$	$0.074x_1$
X_6	Social participation	0.213	–0.061	0.274	$-0.051x_4$	$0.017x_7$	$-0.012x_2$
X_7	Cosmopliteness	0.225	0.000	0.225	$0.203x_{12}$	$0.194x_{10}$	$-0.023x_2$
X_8	Extension contest	0.254	0.167	0.087	$-0.276x_{10}$	$-0.150x_2$	$-0.045x_4$
X_9	Agricultural implements use	0.608	0.475	0.133	$-0.172x_1$	$0.089x_6$	$0.035x_2$
X_{10}	Annual income	0.371	0.116	0.255	$0.062x_2$	$0.052x_9$	$-0.008x_5$
X_{11}	Family type	0.049	0.053	-0.004	$-0.234x_7$	$0.074x_4$	$0.003x_1$
X_{12}	Family size	0.061	-0.066	0.127	$0.184x_{11}$	$0.169x_{13}$	$-0.124x_3$
X_{13}	Occupation	-0.161	-0.070	-0.091	$0.143x_6$	$-0.106x_7$	$-0.008x_{11}$

(Highest indirect effect – Education, Residual effect –0.022)

which is important for ensuring that plants have adequate space to grow and access nutrients, thus enhancing their productivity. Poor adoption rate was observed on alternate drying and wetting of the main field. So the farmers should be adopting these practices to get more yield because it reduces methane emissions from rice fields, improving environmental sustainability. The technique mimics natural drying and wetting cycles, which are beneficial for rice plants and promotes healthy root development. Good rates of adoption were observed in maintaining soil water saturation, keeping drainage channel around sub-plotting, not keeping standing water during transplanting, irrigating one day before weeding, using cono/mandvaweeder for weeding, applying potash in two splits, planting seedlings erect at shallow depth, not keeping standing water during transplanting and irrigating one day before weeding.

Simple correlations are divided into direct and indirect effects in linear structural analysis, also known as path analysis, which is a cause-and-effect relationship. As a result, path analysis was used to break down the impact of socioeconomic characteristics into direct, indirect, and residual impacts. Table 2 shows that the use of agricultural tools has the greatest direct impact on faster adoption of techniques. Similarly, the characteristic education had the strongest indirect influence, showing correlations with the use of agricultural implements, social participation, cosmopoliteness, annual income, housing patterns, and extension contact.

DISCUSSION

The SRI method's success is contingent on optimal water management, which may not be feasible in areas with irregular rainfall or water scarcity. Better adoption were observed on seedling raising of 100 sq meter area transplanting in 1.0 ha land, drainage channel in all sides of seed bed, proper levelling and sowing sprouted seeds in line at shallow depth. Transplanting has to be done at a spacing of 25 x 25 cm being marked with marker to maintain the plant density of 16 hills per meter square. Poor adoption observed on

this practice requires further sensitization to maintain optimum spacing for more effective tillers resulting better production. Keeping seedlings in a thin metal sheet make easy to separate single seedlings from the bunch in transplanting which were not being adopted by majority of the respondents. Further sensitization through effective extension approaches have to be organized for clear understanding about the benefits that may motivate rice growers to adopt SRI. Organic manure improves soil structure as well as multiplication of micro-organisms in soil enhancing more nutrient availability to the plant, the growers have to be sufficiently exposed to realise the benefits which further motivate the growers to adopt green manuring and vermicompost use to supplement organic manure along with nitrogen use in three splits to achieve the desired production. As SRI method of rice cultivation is an organic way, herbicide application is usually avoided. It is therefore suggested to incorporate the weeds into the soil with at least four weeding at 10 days interval. The growers have to be well equipped with detail knowledge and understanding for adoption of the practices. Path analysis illustrates that the attribute education channelized through housing pattern, annual income, extension contact, social participation cosmopoliteness, and use of agricultural implements could exhibit significant influence in increasing the adoption of practices in the SRI method of rice cultivation. As the residual effect is 0.022, it was found that 2.20% of the variation in this relation could not be explained.

CONCLUSION

The System of Rice Intensification (SRI) aims to boost rice production by altering plant, soil, water, and nutrient management. Despite the efforts of Odisha State Department of Agriculture to promote SRI, farmers are discontinuing the practices. Reasons for poor adoption include inadequate nursery bed height (80-100 cm), improper levelling, small bed size (1 x 10 meters), and uneven application of well-decomposed manure. Additionally, transplanting deficiencies include insufficient organic manure, improper spacing (25 x 25 cm), and using thin metal sheets for seedlings. In rice cultivation using the SRI, poor adoption was observed in water management practices, including alternate drying and wetting, irrigating during hairline cracks, and maintaining 2-3 cm of standing water after flowering. Deficiencies in weed management included inadequate weeding (only four at 10-day intervals) and insufficient incorporation of weeds into the soil. To boost yield and encourage SRI adoption, further education on its benefits is essential.

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Research Note

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Constraints in Adopting Improved Cauliflower Cultivation Practices in Hardoi, Uttar Pradesh

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HIGHLIGHTS

- The farmers' most perceived constraints in recommended cauliflower cultivation practices were "More infestation of insect pests and diseases".
- The significant economic constraints faced by cauliflower growers were "High cost of insecticide and pesticides" and "High cost of equipment".
- The significant infrastructural constraints in the adoption of recommended cultivation practices of cauliflower were "Lack of storage facilities" and "High decrease in price at harvesting time".
- The significant credit-oriented constraints perceived by farmers were "Non-availability of credit" and "delay in sanctioning".

ARTICLE INFO

Keywords: Cauliflower cultivation, Farmer constraints, Disease-resistant varieties, Economic constraints, Pest Management, Economic Barriers, Credit Accessibility, Sustainable Farming.

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ABSTRACT

The study examined the constraints faced by cauliflower growers in adopting recommended cultivation practices in Hardoi district, Uttar Pradesh, during the Rabi season of 2021–22. Through multistage random sampling method selected 120 farmers across five blocks and ten villages. The results identified significant technical challenges, including "More infestation of insect pests and diseases" (2.60 MS), reported by 79.16% of farmers, and "Lack of disease-resistant varieties" (2.59 MS). Economic barriers such as "High cost of insecticides/pesticides" (2.54 MS) and infrastructural issues like "Lack of storage facilities" (2.52 MS) were also prominent. Credit constraints, led by "Non-availability of credit" (2.18 MS), further compounded farmers' difficulties. The least significant constraints included "Lack of knowledge about seed treatment" (1.47 MS) and "High cost of irrigation" (1.57 MS). The study concludes that addressing these challenges through enhanced pest management strategies, introducing disease-resistant varieties, and improved economic and infrastructural support could bolster cauliflower cultivation. Such interventions are crucial for improving farmer productivity, ensuring sustainability, and fostering regional agricultural development.

INTRODUCTION

India ranks second globally in producing fruits and vegetables, following China. Among the diverse crops cultivated, cauliflower (*Brassica oleracea* L. var. botrytis) is prominent in the Brassicaceae family. It is a vital horticultural crop valued for its nutritional content and versatility in culinary uses. Originating in the Mediterranean region, cauliflower was introduced to India during

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the British colonial period in the 19th century and has since become a staple in Indian diets. It is rich in vitamin C, vitamin K, dietary fibre, and essential minerals such as calcium, magnesium, phosphorus, and potassium, making it an essential component of a balanced diet (ShunCy, 2023).

Vegetables are vital for public health, contributing significantly to a balanced and nutritious diet. The Indian Council of Medical Research (ICMR) recommends a daily intake of at least 400 grams of vegetables and fruits, accounting for 8 per cent of daily calorie intake (National Institute of Nutrition, n.d.). Despite its nutritional and economic importance, cauliflower cultivation in India is fraught with challenges that restrict its productivity and profitability. Farmers frequently encounter technical, economic, infrastructural, and credit-related barriers that limit their ability to adopt recommended practices. These constraints include pest infestations, high input costs, inadequate storage facilities, and limited access to credit (Gupta et al., 2020). Globally, cauliflower and broccoli cultivation spans approximately 1.34 million hectares, with a production of about 25.2 million tonnes, averaging 18.8 tonnes per hectare (Numerical, 2021). In India, cauliflower cultivation is significant, with major producing states including West Bengal, Madhya Pradesh, Bihar, Gujarat, and Haryana. Uttar Pradesh ranks ninth, with an area of 19,411 hectares and a production of 451,852 tonnes in 2022–23 (Numerical, 2023). Despite its prominence, cauliflower cultivation faces numerous challenges, particularly in regions like Uttar Pradesh, where traditional practices and limited resources often hinder the adoption of improved methods.

The present study investigates the constraints cauliflower growers face in the Hardoi district of Uttar Pradesh, a region with a subtropical climate conducive to Brassicaceae cultivation. This study employs a multistage random sampling approach and a structured interview schedule to identify and analyze these challenges. The findings provide actionable insights to policymakers and extension workers to devise targeted interventions for alleviating these barriers. By addressing the identified constraints, the study seeks to enhance farmer productivity, promote sustainable practices, and contribute to the overall agricultural development of the region.

METHODOLOGY

This study was conducted in the Hardoi district of Uttar Pradesh, India, during the Rabi season of 2021-22. Hardoi has a subtropical climate suitable for cauliflower cultivation in central Uttar Pradesh. A multistage random sampling technique was employed to select respondents. Five blocks within the district were randomly chosen, followed by selecting ten villages from these blocks using simple random sampling with proportional allocation based on village size. Finally, a sample of 120 cauliflower-growing farmers, each cultivating at least half a bigha (0.125 acres) of land, was randomly selected from these villages through proportional allocation. Primary data were collected through personal interviews using a pre-tested, structured interview schedule. The data were coded, tabulated, and analyzed using the Statistical Package for Social Sciences (SPSS) software. Constraints faced by farmers in adopting recommended practices were ranked based on the mean scores obtained for each constraint using a four-point rating scale.

RESULTS

The data in Table 1 revealed that the constraint "More infestation of insect-pests and diseases" (2.60 MS) was the most significant technical constraint perceived by farmers. This issue was identified to a high extent by 79.16 per cent of farmers, to a medium extent by 8.33 per cent, to a low extent by 6.67 per cent, and not at all by 5.83 per cent, placing it at the top rank among technical constraints. The second most significant constraint, "Lack of disease-resistant varieties" (2.59 MS), was reported by 77.5 per cent of farmers to a high extent, by 10 per cent to a medium extent, by 6.67 per cent to a low extent, and not at all by 5.83 per cent. The third-ranked constraint was "Lack of technical guidance" (2.47 MS), followed by "Heavy weed infestation" (2.29 MS) in fourth place. "Lack of knowledge about proper seed rate" (2.19 MS) and "Difficulty in intercultural operations" (2.15 MS) were ranked fifth and sixth, respectively. "Lack of knowledge about spacing" (2.00 MS) ranked seventh, while "Lack of knowledge about seed treatment" (1.47 MS) was the least significant constraint. Only

Table 1. Constraints in adoption of recommended cultivation practices of cauliflower

S. No.	Constraint	MS	Rank	Overall Rank
	Technical constraints			
1.	Difficulty in inter-culture operations	2.15	6	15
2.	Lack of technical resistant guidance	2.47	3	6
3.	More infestation of insect-pests & disease	2.60	1	1
4.	Heavy weed infestation	2.29	4	8
5.	Lack of disease resistant varieties	2.59	2	2
6.	Lack of knowledge about proper seed rate	2.19	5	12
7.	Lack of knowledge about seed treatment	1.47	8	28
8.	Lack of knowledge about spacing	2.0	7	19
	Economic constraints			
1.	High cost of HYVs	2.16	5	14
2.	High cost of insecticides and pesticides	2.54	1	3
3.	High cost of chemical fertilizers	2.24	4	10
4.	High cost of fungicide	2.03	6	18
5.	High cost of weedicide	2.47	3	6
6.	High cost of irrigation	1.57	8	27
7.	High cost of equipment	2.49	2	5
8.	Higher electricity charges	1.9	7	22
	Infrastructural constraints			
1.	Non-availability of seedling	1.84	7	23
2.	Lack of pure insecticides	2.27	3	9
3.	Less availability of irrigation water	1.95	6	21
4.	Lack of transportation	1.96	5	20
5.	Market distance is more	2.20	4	11
6.	Lack of electricity at right time	1.74	8	26
7.	Lack of storage facilities	2.52	1	4
8.	High decrease in price at harvesting time	2.40	2	7
	Credit Oriented Constraints			
1.	Non-availability of credit	2.18	1	13
2.	Inadequacy of credit	2.07	3	27
3.	Unauthorized changes	1.76	4	24
4.	Delay in sanctioning	2.09	2	16
5.	Nepotism and favoritism in providing credit	1.75	5	25

16.67 per cent of farmers perceived this issue to a high extent, 25.83 per cent to a medium extent, 45.83 per cent to a low extent, and 11.67 per cent did not face this constraint. These findings align with Anamika et al., (2023) & Kumari et al., (2022).

The constraint "High cost of insecticides/pesticides" (2.54 MS) was farmers' most significant economic challenge. This issue was perceived to a high extent by 75 per cent of farmers, to a medium extent by 10.83 per cent, to a low extent by 7.5 per cent, and not at all by 6.67 per cent, earning it the top rank among economic constraints. The second-ranked constraint, "High cost of equipment" (2.49 MS), was reported by 73.33 per cent of farmers to a high extent, 4.67 per cent to a medium extent, 5.83 per cent to a low extent, and 9.16 per cent not at all. "High cost of weedicide" (2.47 MS) was ranked third, followed by "High cost of chemical fertilizers" (2.24 MS) in fourth place. "High cost of HYVs" (2.16 MS) was ranked fifth, while "High cost of fungicide" (2.03 MS) and "High electricity charges" (1.90 MS) were ranked sixth and seventh, respectively. The constraint with the lowest rank was "High cost of irrigation" (1.57 MS), perceived to a high extent by 28.33 per cent of farmers, to a medium extent by 13.33 per cent, to a low extent by 40.83 per cent, and not at all by 17.5 per cent. These findings align with those of Gupta et al., (2023) & Roy et al., (2022).

"Lack of storage facilities" (2.52 MS) was the most significant infrastructural constraint, as it was perceived to a high extent by 75 per cent of farmers, to a medium extent by 10.83 per cent, to a low extent by 5.83 per cent, and not at all by 8.3 per cent. This constraint ranked first among infrastructural challenges. The second-ranked constraint was "High decrease in price at harvesting time" (2.40 MS), perceived to a high extent by 71.16 per cent of farmers, to a medium extent by 9.16 per cent, to a low extent by 6.67 per cent, and not at all by 12.5 per cent. The third rank was awarded to "Lack of pure insecticides" (2.27 MS), while "Market distance is more" (2.20 MS) was ranked fourth. "Lack of transportation" (1.96 MS) was awarded the fifth rank, followed by "Less availability of irrigation water" (1.95 MS) in sixth place. The constraint "Non-availability of seedlings" (1.84 MS) was ranked seventh. The least significant constraint was "Lack of electricity" (1.74 MS), perceived to a high extent by 19.16 per cent of farmers, to a medium extent by 46.67 per cent, to a low extent by 23.33 per cent, and not at all by 18.33 per cent. The high cost of establishing cold storage facilities might explain the prominence of the "Lack of storage facilities" issue. Similar findings were reported by Das et al., (2014) & Kumari et al., (2022).

The constraint "Non-availability of credit" (2.18 MS) was the most significant credit-oriented challenge faced by farmers. It was perceived to a high extent by 60.50 per cent of farmers, to a medium extent by 24.16 per cent, to a low extent by 20 per cent, and not at all by 5.8 per cent, earning it the top rank among credit-related constraints. "Delay in sanctioning" (2.09 MS) was ranked second, perceived to a high extent by 35 per cent of farmers, to a medium extent by 43.33 per cent, to a low extent by 17.5 per cent, and not at all by 4.16 per cent. The third-ranked constraint was "Inadequacy of credit" (2.07 MS), followed by "Unauthorized changes" (1.76 MS) in fourth place. The least significant constraint was "Nepotism and favouritism in providing credit" (1.75 MS), perceived to a great extent by 21.67 per cent of farmers, to a medium extent by 38.33 per cent, to a low extent by 33.33 per cent, and not at all by 6.67 per cent. These findings align with Kumar et al., (2020) & Sabu et al., (2024).

DISCUSSION

The multifaceted constraints identified in cauliflower cultivation can be attributed to several interconnected factors, as revealed through both survey data and farmers' insights. During the field survey, farmers frequently reported that pest infestation (2.60 MS) was a significant challenge. Several farmers expressed frustration over the limited effectiveness of pesticides, which has increased their reliance on costly chemical solutions. This finding aligns with broader trends observed in Uttar Pradesh and other cauliflower-growing regions, where Brassica crops are highly susceptible to pests and diseases due to changing climate patterns (Yadav et al., 2018; Gupta et al., 2020). The lack of disease-resistant varieties (2.59 MS) further aggravates the issue, with farmers highlighting the scarcity of resilient seeds, a challenge also reflected at the regional level due to slow cultivar development. The high cost of agricultural inputs, particularly pesticides and insecticides (2.54 MS), emerged as a recurring issue. Farmers noted that rising input costs reduce their profit margins, forcing them to limit pesticide application or opt for lower-quality alternatives. This trend mirrors broader market inefficiencies, driven by import dependencies and fluctuating chemical prices (Kumar et al., 2020; Kumar et al., 2023). The inadequate storage facilities (2.52 MS) were frequently cited as a significant infrastructural constraint. Many farmers shared that due to the perishable nature of cauliflower, they were often compelled to sell their produce immediately after harvest, even at lower prices, due to the lack of cold storage options. This situation reflects the larger issue of insufficient rural storage infrastructure in India, which continues to hinder farmers' bargaining power.

Furthermore, the price fluctuations at harvest time (2.40 MS) were highlighted as a significant challenge, with farmers expressing concerns over low farmgate prices and limited access to formal market linkages. This issue is exacerbated by the absence of efficient value chains and organized procurement systems, making smallholder farmers vulnerable to market volatility (Kumari et al., 2022). Credit constraints (2.18 MS) further compound the challenges, with farmers struggling to access loans due to complex documentation and limited rural banking reach. These constraints are interconnected, as high input costs and storage issues reduce profitability, making farmers more dependent on credit. Addressing these challenges requires holistic interventions such as better seed access, improved storage infrastructure, and streamlined credit facilities (Kumar & Nain, 2012).

CONCLUSION

Farmers primarily struggle with pest infestations, high input costs, inadequate storage facilities, and limited access to credit, which hinder their ability to adopt sustainable farming practices. These findings emphasize the need for targeted interventions, such as improved technical support, affordable input options, and better

credit facilities, to enhance the adoption of recommended practices and ensure sustainable cauliflower cultivation. Addressing these constraints can lead to increased productivity and profitability for farmers, thereby contributing to the region's overall agricultural development. The study reaffirms the importance of providing farmers with the necessary resources and support to overcome these challenges and improve agricultural practices.

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Economic Impact of Extension Interventions on Composite Carp Culture in Dhenkanal and Kandhamal, Odisha

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HIGHLIGHTS

- Scientific carp culture significantly increased fish production across all adopted ponds.
- Higher investments in feed, seed, and pond management resulted in improved profitability.
- Return on Investment (ROI) improved post-intervention, reaching up to 169 per cent in Kandhamal whereas Benefit-Cost (B:C) ratio showed notable improvement, confirming the economic feasibility of scientific practices.
- Enhanced training and awareness among farmers contributed to better adoption and success rates.

ARTICLE INFO

Keywords: Composite carp culture, Aquaculture, B:C ratio, Return on investment, Scientific carp culture technology.

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ABSTRACT

The aquaculture sector is rapidly growing, significantly contributing to the Indian and global economies by ensuring nutritional security and supporting livelihoods. Composite carp culture is one of the most extensively used technology. The study was carried out in Dhenkanal and Kandhamal districts of Odisha attempts to determine whether composite carp farming is economically viable by examining the costs and benefits of the technology. Data were collected from 220 fish farmers of both Dhenkanal and Kandhamal districts before and after adoption of Scientific carp culture technology. The total pond area was 3.6 ha in Dhenkanal and 3.7 ha in Kandhamal district. The mean fish yield was 1047.1 kg/ha/yr and rose to 2032.1 kg/ha/yr in Dhenkanal and 1247.2 kg/ha/yr to 2554.5 kg/ha/yr in Kandhamal. Rate of return on total investment (ROI) and Benefit-Cost ratio (B:C ratio) of Dhenkanal and Kandhamal ponds, after intervention was worked out as 124.7 per cent, 1.2 and 169 per cent, 1.7 respectively. Supplementary feed accounted for the largest portion of the cost of fish production, followed by pond leasing value and pond preparation costs. The study suggests that the composite carp culture method is economically viable and has a remarkable benefit-cost ratio.

INTRODUCTION

The aquaculture sector is experiencing rapid expansion globally, driven by a rising demand for fish and seafood products (Mondal et al., 2024). Fisheries and aquaculture are significant sources of food, nutrition, financial resources, and employment in India. Fish production plays a crucial role in socioeconomic status of rural population in India (Dutta et al., 2022). India is the world's third largest fish-producing country, accounting for 7.96 per cent of worldwide production, as well as the world's second-largest aquaculture producer. Odisha reported at 10.52 MMT production in 2023 (CEIC, 2023). Three significant reservoirs are located in Odisha: Rangali in Dhenkanal district (28,000 ha), Hirakud in Sambalpur (71,963 ha), and Balimela in Koraput district (19,440 ha). These diverse water bodies contribute to the state's rich fish biodiversity (Das et al., 2021). The Dhenkanal District is 4,452 square kilometers in size. The district has ponds and tank resources of 1,749.22 ha, which accounts for 1.32 per cent of the

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ponds and tank resources of Odisha. Freshwater fish production in Dhenkanal district was 10,232.46 MT in 2017-18, contributing 2.2 per cent towards total freshwater fish production of Odisha (Shasani, 2020). Kandhamal experiences sub-tropical hot and dry climate in summer. Dry and cold climate in winter. The maximum temperature recorded in the District is 45.5°C and minimum temperature is 2.0°C. Almost 66 per cent of the land area of the district is covered with dense forests and towering mountains. The important crops grown in the district during the Kharif season are paddy, maize, and niger. In irrigated areas, crops like potato, vegetables, and mustard are grown. Kandhamal is one of the most backward districts of Odisha, with 47.2 per cent of households in the BPL category as recorded in the year 2000 (District Annual Plan Document, 2013-14, Kandhamal). The district is a major producer of ginger and turmeric and has created a name for itself in India for spice cultivation. Coming to aquaculture, Limited water resources and poor water quality restrict fish production in Kandhamal, making the district reliant on Andhra Pradesh for fish supply. To address this, the administration plans to scale up local production through SHGs under the Odisha Livelihood Mission (OLM) (Sahoo et al., 2021). Aquaculture systems need to be established using sound scientific and economic evaluation (Manju Lekshmi et al., 2019). Under one DST funded project "Economic Empowerment of SC fish farmers through capacity building in two aspirational districts Dhenkanal & Kandhamal, Odisha" composite carp culture was promoted among selected beneficiaries during 2022-24. It is imperative to know how this technology is performing better as compared to traditional way of farming fish. Economic assessment of this technology is attempted in this article. Effective communication plays a vital role in advancing scientific fish farming practices by facilitating knowledge exchange, problem-solving, market awareness, and collaboration among stakeholders (Mondal et al., 2024). To ensure sustainable and profitable IMC aquaculture, it is essential to adopt an integrated approach that encompasses various aspects of pond cultivation, nutrition, and health management (Manam & Quraishi, 2024).

METHODOLOGY

The study was carried out in eleven adopted ponds of Dhenkanal and Kandhamal district. The data was collected from the selected beneficiaries of both the districts. The profitability of composite carp culture was evaluated using the Gross Margin Analysis (GMA) method. GMA is a valuable measure for determining farm profitability. The gross margin (GM) is the difference between the fish farm's total revenue and the total variable costs required to generate the output (Firth, 2002). The whole output multiplied by the cost per unit of fish is the total income. The costs that vary according to the level of production are known as variable costs. The entire variable cost includes food, labour, shipping, fertilizers, and other input expenditures like fingerlings. The above discussion can be represented by the following equation:

Gross Margin = Total Revenue – Total Variable Cost

In order to determine the profitability of the suggested plan, the rate of return on total investment is computed as follows:

ROI = (Total Revenue / Cost of Production) * 100

B:C Ratio = Total Revenue / Cost of Production

In the above formula the term Total Variable Cost (TVC) refers to all variable cost elements, such as feed, fertilizer, lime, seed, and inputs. The whole revenue was made up of other farm income and the revenues from the sale of fish. Gross Margin is the total revenue minus all variable costs. The data was analyzed using budgeting and percentage analyses. The information gathered was from July 2022 to June 2023. The tabulated data was evaluated using appropriate statistical procedures, namely frequency and percentage. To determine profitability, a thorough economic assessment of composite carp culture technology is essential. This will make it possible for development professionals to inspire and bring in more fish farmers and young people from remote areas to use the technology. In the districts of Dhenkanal and Kandhamal, a research on input usage and net profit was conducted in adopted ponds. On a per-hectare basis, Table 2 illustrates the costs, yields, and profit from composite carp farming.

RESULTS

Comparison of pre and post intervention production of adopted ponds

Table 1 represents a comparison of fish production before and after the intervention in various adopted ponds across Dhenkanal and Kandhamal districts. The data indicate significant improvements in fish yield due to scientific carp culture practices. In Dhenkanal,

Table 1. Comparison of Pre and Post Intervention Production of adopted ponds

District	Village Name	Pond Name	Pond Area (ha)	Production before Intervention (kg/ha)	Production after Intervention (kg/ha)
Dhenkanal	Raitala	Chabaka	0.2	875	1457
Dhenkanal	Raitala	Village Pond (New)	0.6	925	1755
Dhenkanal	Raitala	Village Pond (Community)	0.6	933	1855
Dhenkanal	Raitala	Nua Pokhari	0.2	867	995
Dhenkanal	Sankulei	Sankulei Pond 1	0.4	870	1353
Dhenkanal	Sankulei	Sankulei Pond 2	0.4	1041	1925
Dhenkanal	Namichira	Namichira Pond	1.2	1285	2790
Kandhamal	Pankangaon	Pond 1	0.4	950	1953
Kandhamal	Pankangaon	Pond 2	0.2	525	765
Kandhamal	Phiringia	Pond 3	0.6	925	1800
Kandhamal	Balandapada	Pond 4	2.5	1430	2975

Table 2. Economics of composite carp culture in both the districts; Dhenkanal & Kandhamal

S.No.	Particulars	Dhenkanal		Kandhamal	
		Local Practice	Scientific Carp Culture	Local Practice	Scientific Carp Culture
1	Area (ha)	3.6	3.6	3.7	3.7
2	Lease Value (Rs)	18720.0	19500.0	17550.0	18000.0
3	Manuring (Rs)	9500.0	10000.0	12250.0	11500.0
4	Lime (Rs)	9600.0	10560.0	9723.0	10192.0
5	Seed (Rs)	25500.0	40000.0	17500.0	40000.0
6	Feed (Rs)	78000.0	183000.0	85560.0	165000.0
7	Harvest cost (Rs)	11100.0	12550.0	10200.0	11300.0
8	Cost of labour, maintenance & misc (Rs)	1000.0	1500.0	1300.0	1000.0
9	Cost of Production	153420.0	277110.0	154083.0	256992.0
10	Total Variable Cost (Rs)	134700.0	257610.0	136533.0	238992.0
11	Total Production kg/ha	1047.1	2032.1	1247.3	2554.5
12	Total Revenue	167537.8	345457.0	199567.6	434265.0
13	Gross Margin	32837.8	87847.0	63034.6	195273.0
14	Rate of return on total investment (ROI)	109.2	124.7	129.5	169.0
15	B:C Ratio	1.1	1.2	1.3	1.7

production increased from 875 kg/ha to 1,457 kg/ha in Chabaka pond, while the Namichira pond recorded a substantial rise from 1,285 kg/ha to 2,790 kg/ha. Similarly, in Kandhamal, Pankangaon Pond 1 experienced an increase from 950 kg/ha to 1,953 kg/ha, and Balandapada Pond 4 saw an increase from 1,430 kg/ha to 2,975 kg/ha. These improvements indicate that scientific practices significantly enhanced production efficiency across all ponds. Similarly Debnath (2024) reported in Tripura's Dhalai district the composite fish culture intervention significantly boosted aquaculture increasing fish yields from 305-380 kg/ha to 934-1577 kg/ha in three years, a 206-315% rise enhancing farmers' profits.

Economic analysis of composite carp culture

Table 2 provides a detailed economic analysis of composite carp culture in Dhenkanal and Kandhamal districts. The cost of production increased post-intervention due to additional investments in quality inputs such as feed, seed, and pond preparation. In Dhenkanal, production costs rose from Rs. 1,53,420 to Rs. 2,77,110, while in Kandhamal, they increased from Rs. 1,54,083 to Rs. 2,56,992. However, this increase in investment resulted in higher yields, leading to greater profitability. The total production per hectare increased from 1,047.1 kg to 2,032.1 kg in Dhenkanal and from 1,247.3 kg to 2,554.5 kg in Kandhamal. As a result, the gross margin rose from Rs. 32,837.80 to Rs. 87,847.00 in Dhenkanal and from Rs. 63,034.60 to Rs. 1,95,273 in Kandhamal. Return on Investment (ROI) improved from 109.2 per cent to 124.7 per cent in Dhenkanal and from 129.5 per cent to 169.0 per cent in Kandhamal. Similarly, the Benefit-Cost (B:C) ratio increased from 1.1 to 1.2 in Dhenkanal and from 1.3 to 1.7 in Kandhamal. These figures confirm that the adoption of scientific carp culture resulted in significantly higher productivity and profitability. De et al., (2022) also reported that commercial feed-based systems yield higher profits compared to extensive farming methods without feed, thereby justifying the increased investment costs.

DISCUSSION

The significant rise in fish production and economic gains can be attributed to the adoption of scientific carp culture techniques. As shown in Table 1, the increase in yield across all ponds was driven by improved pond management, optimized feeding practices, and higher stocking densities. The use of high-quality supplementary feed and increased stocking rates played a crucial role in accelerating fish growth, ultimately leading to greater production. Furthermore, proper pond preparation, including appropriate liming and manuring, enhanced water quality and contributed to higher fish survival rates. Differences in production levels among ponds were influenced by factors such as pond size, efficiency in water management, and the degree of adherence to recommended scientific practices. Ponds with better management and larger areas demonstrated superior performance. This highlights the importance of targeted training and awareness programs to promote the consistent adoption of best practices among fish farmers.

Dickson et al., (2016) emphasized that best management practice training was initially designed to enhance overall farm efficiency, which in turn was expected to provide environmental benefits through improved feed utilization. This aligns with the findings of the present study, where effective training and implementation of scientific practices have played a crucial role in increasing fish production and economic returns. The economic impact, as outlined in Table 2, reinforces the profitability and viability of scientific carp culture. Although production costs increased, the resulting rise in revenue and net profits justified the investment. The higher expenditure on quality inputs such as feed and seed played a critical role in maximizing productivity. The enhanced Return on Investment (ROI) and Benefit-Cost (B:C) ratio in both districts demonstrate the economic viability of adopting scientific carp culture. Notably, Kandhamal exhibited significant improvements, with ROI rising from 129.5 per cent to 169.0 per cent and the B:C ratio increasing from 1.3 to 1.7. Similarly, De et al. reported that ROI for adopters and non-adopters was 85.84 per cent and 63.03 per cent, respectively, while the B:C ratio was calculated at 1.86 for adopters and 1.63 for non-adopters. These findings indicate that factors such as better market access, favorable environmental conditions, and efficient management played a crucial role in achieving superior results. Singh (2019) reported that fish harvests increased by up to 164 per cent following the adoption

of Composite Fish Farming (CFC). Comparative studies between CFC and traditional methods demonstrated higher gross and net profits, with benefit-cost ratios of 2.36 and 1.83, respectively. Research by Singh (2007); Ananth et al., (2014) & Chouhan (2015) has shown that farmers with a profit-maximization approach are more likely to adopt CFC systems. Additionally, Singh (2006) highlighted a positive correlation between fish farming income and overall family earnings. Studies by Ali et al., (2008); Paik et al., (2010); Gupta & Dey (2015) have suggested that increasing fish production can help reduce income inequality, as productivity is influenced not only by environmental factors but also by socio-economic and management practices. Olasunkanmi (2012) found that fish farming, with a benefit-cost ratio of 1.65 and a profit-cost ratio of 0.65, was a profitable venture, recommending greater investment in essential inputs like feed, lime, and fingerlings while minimizing labor and fertilizer costs.

CONCLUSION

Carp fry survival and growth are mostly dependent on appropriate supplementary feeding with nutritionally balanced diets, which significantly boosts Indian major carp output in ponds. Diets should include 30-40 per cent protein, 6-8 per cent lipids, and necessary vitamins and minerals. Feeding multiple times, a day, using appropriate pellet sizes, and ensuring even distribution improve feed intake and growth. Regular water quality monitoring, aeration, and water exchange maintain optimal living conditions. Incorporating probiotics and maintaining hygiene prevent disease. These practices lead to higher survival rates, faster growth, and increased production yields, making aquaculture operations more successful and profitable. The B:C ratio of fish farmers increased dramatically on adopting scientific carp culture technology compared to control farmers. This empirical study found that carp culture is profitable, with adopters of scientific technology having a gross margin more than twice that of non-adopters. This indicates that improved fish farming methods can help farmers improve their socioeconomic status.

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Research Note

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Analyzing Adoption Impediments in Soil Health Card based Fertilizer Application by Farmers

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HIGHLIGHTS

- Education, social participation, mass media exposure, extension participation and farmer's income level had a non-significant relationship with perception of Soybean and Wheat cultivators about the utility of Soil Health Card based
- The full adoption of SHC based application of fertilizers dose by farmers was near to 10 percent, partial adoption by 50 per cent and no adoption by 41 per cent.

ARTICLE INFO

Keywords: Soil Health Card (SHC), Adoption impediments, Soybean and Wheat crop, Correlation analysis.

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ABSTRACT

The study was completed in Harda district of Madhya Pradesh. Present study was completed in the year 2023. The average data of continuous SHC based study and extension based responses were collected through developed interview schedule, random group discussion, meetings and personal interviews and data was analyzed to find out the adoption extent, impediments, regarding of soil health card based recommendations among farmers of different villages provided or benefited under different schemes of state departments and Krishi Vigyan Kendra and line departments. The importance of soil health card based fertilizers use was told to farmers before the response collection in the initiation of crop season through training and other awareness programmers. The impediments were recorded to know the status of adoption of soil health card based fertilizers application among farming community in Soybean and Wheat major crops. The continuous motivation of educated farmers having good social participation and mass media exposure by KVK scientists through conducting SHC based trials and demonstrations, backstopping by field extension activities and success story sharing have significant role in enhancing the adoption rate and balance use of fertilizers dozes for improving farmers income and cost saving in Harda district of Madhya Pradesh.

INTRODUCTION

Madhya Pradesh is one of the leading states as recipient of Krishi Karman Award since 2011-12. Madhya Pradesh has received this award 7 times till 2025. The Krishi Karman Awards was given for total food grain production category in year 2011-12, 2012-13 and 2014-15 for wheat production in 2016-17 followed pulse production in year 2017-18 (PRO-MP, 2025). The malawa region of MP state has maximum contribution in overall production of cereals and pulses. The district Harda has witnessed the highest productivity of wheat and Chickpea in the state many times. The farmers of this region are used to chemical fertilizers more than recommendations; therefore the suitability of soil health card was more to create wide awareness and importance of judicious use of fertilizers doze by farmers. The competiveness of highest production of food and pulse grains among farmers was also seen which makes the study more just to the topic. The soil health card (SHC) a printed document prepared in soil testing lab by experts

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was furnished to the farmers for important information on the major available soil nutrients. The recommendations doze of chemical fertilizers was circulated to sustain productivity and soil health. Farmers of this region used three crops cultivation continuously round the year due to canal irrigation availability in rabi and summer season. The reason being farmers were using enough quantity of chemical fertilizers in their crops for exploiting maximum yield. The common perception observed that the reduction in fertilizers doze may reduced their production of crops as also witnessed in Haryana state (Ohlan et al., 2025). The use of soil health card is more important to get good yield and for better soil health. Although, the soil health card scheme found beneficial for farmers. Farmers were motivated for adoption of soil health card based recommendations by scientists and extension workers. There is need to assure famers that by using recommended doses and by cutting over doses of fertilizers they can get maximum yield. Farmers who were aware of this soil health testing scheme but still unable incorporate recommendations doze due several constraints like unavailability of input during the showing time, lack of capital to purchase fertilizer, technical knowledge, difficult to understand SHC dose application and other personal socio-psychological barriers.

The SHC adopter farmers have reduced their usual doses of Nitrogen, Phosphorus and Potash especially nitrogen helped them reduce the fertilizer use which ultimately leads to decrease in cost of cultivation (Reddy, 2017). It has been witnessed by many reports in our country that the chemical fertilizer use was reduced by the adopter farmers about in the range of 8-10 per cent in average. The adoption of SHC based fertilizers use for cost saving and soil health improvement is necessary may be boost up by incorporation at farmers field level through creating wide awareness, knowledge about use of ICTs tools, social media, pluralistic extension strategies, KVKs, line departments, para extension services and adoption other innovative extension methodologies (Kumar et al., 2015; Kumar et al., 2020).

METHODOLOGY

As per the above discussed background this efforts was made to receive the farmer's response and different impediments faced by the farmers for using the recommendation of soil health cards at their field level in Harda district of Madhya Pradesh. The information was collected through developed interview schedule from Harda district. The Harda district is comprised of three blocks namely Harda, Timarani and Khirkiya from each block four Panchayats were selected randomly and from each Panchayat 25 Soil Health Card holding farmers were duly selected randomly for colleting the information used in this study. Thus, from 12 panchayats a total of 300 farmers were interviewed and their response were analyzed by using statistical tools as correlation, percentage and frequency to make the discussion more rationale. The response of the framers was recorded who were due taught about importance of soil health cards in crop production by KVK scientists, line departments, para extensions workers through cumulative extension activities time to time in the whole district. The collected responses of farmers were tabulated and summarized in scientific manner for putting them in different response categories for making the presentation more meaningful. The weather parameters, availability of inputs at sowing time and during critical need also were taken cared as parameter for adoption of all soil health card based recommendation by the farmers. Study was completed during 2021-2023.

The lab tested sample based recommendations shown in soil health cards were used as such above 75 per cent by farmers were considered as full adoption. When the recommendations shown in soil health card and used 35 to 75 per cent by farmers were categorized as partial adoption and the farmers who have used soil health card recommendation below 35 per cent were put under no adoption category in this study. The different impediments faced by famers for smooth adoption and practice the information were also recorded and instant solutions were also being facilitated to the respondent farmers during study by scientists and other extension personnel in the district.

RESULTS

The major impediments for not adoption of soil health card based fertilizers dose by the SHC holder famers was perceived due to lack of capital availability to purchase fertilizers (13.33% farmers) followed by unavailability of fertilizers during need (13.00% farmers) in case of soybean crop. In case of wheat crop again no adoption seen due to unavailability of fertilizers during need (19.00% farmers) followed by lack of capital availability to purchase fertilizers by (9.67% farmers). The findings are witnessed by Singh et al., (2023) & Charel et al., (2018). The major impediments responsible for partial adoption in case of soybean crop were perceived as lack of capital availability to purchase fertilizers by (18.33% farmers) followed by personnel socio-psychological barriers by (12.00% farmers). In case of wheat crop the unavailability of fertilizers during need by (14.67% farmers) followed by lack of capital availability to purchase fertilizers by (12.33% farmers). The above finding is in line with a study done by Kumar & Rani (2018) & Jayalakshmi et al., (2021).

Table 1. Major impediments for partial and non adoption of SHC based fertilizer doses

Major impediments	Soybean Crop		Wheat Crop	
	Partial Adoption (%)	No Adoption (%)	Partial Adoption (%)	No Adoption (%)
Unavailability of fertilizers during need	8.00	13.00	14.67	19.00
Lack of capital availability to purchase fertilizer	18.33	13.33	12.33	9.67
Lack of technical knowledge	2.67	1.67	4.33	2.00
Difficult to understand SHC dose application	2.00	1.67	3.33	1.00
Report was not available on crop sowing time	7.00	8.00	5.33	6.67
Personal socio-psychological barriers	12.00	3.33	10.00	2.67

Table 2. Socio-economic variables relationship with the adoption of SHC based recommendations

S.No.	Variables	Correlation coefficient
1	Age	0.042
2	Education	0.488*
3	Family size	0.034
4	Social participation	0.338*
5	Mass media	0.376*
6	Extension participation	0.506*
7	Land holding	0.041
8	Farmers income	0.336*

*5% level of significance

The correlation analysis of perception indicated that the positive and significant relationship at a five percent level with education, social participation, mass media exposure, extension participation and farmer's income level whereas age, family size and land holding had a non-significant relationship with perception of Soybean and Wheat cultivators about the utility of Soil Health Card based recommendations in crop production. The acceptance of Soil Health Cards (SHCs) by the Soybean and Wheat crops cultivators exhibits a diverse response, with several significant factors influencing the adoption rates of fertilizers doses at field and farmer's level. The all significant variables are positively associated with adoption levels and indicating their pertinent roles in influencing farmer adoption behavior towards SHCs based fertilizers recommendation. On the other hand non significant variable has not positive impact on adoption rates of the said practices. The above findings are also being witnessed by Chaudhary & Theodore (2016); Madhuri et al., (2024) & Lal et al., (2025).

DISCUSSION

The present study has revealed the full adoption by fewer respondents beyond good backstopping efforts by KVK scientists and other extension personnel. The study revealed that the different impediments face by farmers in adoption of soil health card based fertilizers recommendation in their crops like unavailability of fertilizers and other agri-inputs during critical need of application, lack of capital availability to purchase fertilizer round the year, lack of technical knowledge to use different inputs and their role for crop yield, difficult to understand soil health card based dose application in the crops, sometime the soil testing report was not available on crop sowing time and other several personal socio-psychological barriers that found responsible to hinder the adoption of this technology. There were several socio-economic and personal variables were studied and found in the line of referenced researchers but in my study the economic status or farmers income was found significantly correlated to adoption of soil health card based recommendation because of the purchasing power, handling and storage facilities of agri-inputs in the district. The less resourceful farmers sometime get reluctant in using the inputs and soil testing, soil sample collection and sending to lab perceived as tedious job hence less adoption rate was witnessed among this group of farmers. The regular use of potash was also not practiced by farmers followed by zinc at the different intervals. The study done by Madhuri et al., (2024), shown that the annual income of paddy growing farmers was found non significant in adoption of soil health card based recommendation in the Andhra Pradesh during 2023-2024 and but in same way the economical benefits reaped significantly by soil health card used farmers in MP said by Singh & Kushwah (2020) followed by integrated fertilizer management was seen economical beneficial for paddy famers in Jharkhand state by Jha et al., (2021) & Ankhila et al., (2023).

The strong extension network at grassroots level of farmers still a need for improving their crop yields, crop diversification, and innovation, hi tech based technical interventions. The technological failure compensation responsibility may be taken into consideration by the concerned extension institute or government, this may enhance the adoption and penetration rate of any new technology, practice, methods or input or recommendation in the farming community. The integrated efforts of KVK scientists, line departments, para extension workers, NGOs, volunteer organization and farmer to farmer extension, different levels of partnership as part of pluralistic approach may by fruitful to boost adoption rate different scientific recommendations and expected results. The social media is also played very crucial role in transforming the agricultural growth and management, marketing linkages, transportation, and round the year supply of different agriculture produce with sustainable value chain in the country. The present findings related to adoption and economical impact of SHC is being aligned with Sahay et al., (2019); Subhash et al., (2019) & Patel et al., (2021).

CONCLUSION

The farmer's education status, income, social participation, mass media exposure played an important role in decision making and adoption at field level by without creating doubts and fear of yield loss. The non availability of fertilizers at critical time and less purchasing power of farmers, traditional mindset found as major impediments in adoption of SHC based recommendations of fertilizers. The continuous motivation by para extension workers, line department and KVK scientists play significant role in enhancing the adoption rate and balance use of fertilizers dozes for improving farmers income and cost saving in Harda district of Madhya Pradesh.

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Research Note

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Understanding and Overcoming Key Challenges of Agripreneurs in Southern Odisha: A Case Study

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HIGHLIGHTS

- Agripreneurs in Southern Odisha face numerous challenges, including a lack of technical knowledge, financial difficulties, and personal-social issues.
- Key recommendations to address these barriers include establishing comprehensive support systems for financial aid and expert guidance.
- The study used the RBQ method to identify and prioritise constraints, offering actionable insights to foster rural development and sustainable agriculture.

ARTICLE INFO

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ABSTRACT

The study, conducted during 2023 and 2024, investigates the constraints faced by agripreneurs in Southern Odisha and provides actionable suggestions to address these challenges. Data were collected from 120 agripreneurs across the Gajapati and Rayagada districts using personal interviews and random sampling. The collected data were analysed using the Rank-Based Quotient (RBQ) method to identify and prioritise key barriers. The findings revealed that knowledge and skills constraints ranked highest (66.07), highlighting inadequate technical expertise, lack of awareness, and insufficient training. Financial constraints followed (57.24), emphasising high risk, complex bank loan procedures, and substantial initial capital requirements. Personal and social challenges (53.37) and psychological limitations (49.78) were also identified but ranked lower. The study's recommendations, supported by word cloud analysis, stress the need for financial support, risk mitigation strategies, access to modern technologies, and expert advice. Suggested interventions include simplifying loan procedures, providing skill development programs, and fostering a supportive entrepreneurial ecosystem. The study addresses barriers to agripreneurship in Southern Odisha and may enhance agripreneurs' potential, promote sustainable agricultural development and rural economic growth, and provide valuable insights for policymakers and stakeholders by emphasizing skill development and technological integration.

INTRODUCTION

Agriculture in India is essential for millions of farmers, particularly in rural regions. Agripreneurship, which refers to entrepreneurial initiatives within agriculture, is vital to rural development. Agripreneurs use new strategies, improve production, and stimulate economic development by connecting traditional farming with contemporary agribusiness (Gupta et al., 2023). Agripreneurs drive technology innovations, enhance supply chain efficiency, and advocate for sustainable agricultural practices. They

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diversify agriculture via agri-processing, organic farming, and agri-tourism, therefore strengthening rural communities and invigorating local economies. However, their efforts are often hindered by challenges such as restricted market access, inadequate financial resources, insufficient technical expertise, intellectual property management, funding, and a lack of infrastructure assistance (Bihari et al., 2024). These constraints are particularly pronounced in regions like Southern Odisha, where agripreneurs face additional barriers due to socio-economic and geographical factors. Understanding these region-specific limitations is essential for developing targeted strategies to improve productivity, sustainability, and overall agripreneurial success.

Southern Odisha, characterised by its diverse agricultural practices and extensive rural population, presents unique challenges for agripreneurs. These challenges include restricted market access, limited financial resources, lack of technical knowledge, and inadequate infrastructure (Ferguson et al., 2024). The region is further impacted by climate change, which poses significant threats to agricultural yields and production, while fragmented land ownership hampers economies of scale (Suman et al., 2025). The limited availability of quality inputs such as seeds, fertilizers, and irrigation infrastructure exacerbate these difficulties (Mishra et al., 2024). Inefficient supply chain mechanisms and inadequate storage facilities contribute to post-harvest losses, thereby diminishing profitability. Social and cultural barriers, including marginalization and gender inequities, further compound these issues (Saha et al., 2025). Despite various policy initiatives supporting agripreneurs in Odisha, such as Mukhyamantri Krushi Udyog Yojana (MKUY), Odisha Startup Policy, and Odisha Agricultural Policy 2020, gaps in effective policy implementation remain, including insufficient awareness and accessibility, and bureaucratic hurdles. Addressing these gaps through targeted policy reforms and improved outreach can enhance agripreneurial growth and rural economic development in Southern Odisha.

Agripreneurs in India are advocating for better agricultural techniques and business initiatives. They emphasize the need for increased access to financing, including affordable credit and government-backed loans, as well as stronger market linkages. Skill development and training programs (Arunkumar et al., 2021), agri-tech advancements, and sustainable practices are also crucial (Kumari et al., 2024). Infrastructure upgrades, such as improved storage facilities, cold chains, and transportation networks, are essential. Additionally, agripreneurs call for supportive government policies and incentives, such as subsidies for inputs, tax advantages, and extension services, to create a more conducive environment for agricultural entrepreneurship in India. This research explores the restrictions encountered by agripreneurs in Southern Odisha using the Rank-Based Quotient (RBQ) approach (Saha et al., 2024). The region's agricultural potential is vast but underdeveloped owing to socio-economic and infrastructure challenges. Addressing these restraints is vital for unleashing the region's full potential and allowing agripreneurs to contribute more effectively to the local and national economy.

METHODOLOGY

The research design used for the study was the Ex post-facto design. The study focused on the Gajapati and Rayagada districts in southern Odisha (Figure 1), selected for their large number of cashew processing units and agri-enterprises. A total of 120 Agripreneurs, with 60 from each district, were chosen from various agricultural sectors for the study by using the random sampling technique. The data collection tool was developed keeping in view the objectives and variables of the research. Personal interviews were used to collect data. Major constraints taken for the study were identified through initial discussion with experts and respondents, as well as from the literature review. Three statements under 4 barrier groups were considered, and respondents were asked to rank these constraints: rank 1 being the most severe, rank 2 being the moderately severe, and rank 3 being the least severe. Qualitative data were gathered through interactive discussion with key informants, and literature, journals and data available on the internet were the key resources for secondary data. The rank-based quotient (RBQ) method was used to analyse the collected data (Sabaratnam & Venilla, 1996).

The RBQ-Rank Based Quotient is a method used to prioritize alternatives based on their relative rankings. The study involved three statements under four barrier domains, with respondents ranking them based on perceived severity. The highest RBQ value was chosen as the most severe constraint, and the cumulative rank for each barrier was determined by obtaining the mean RBQ value. The study aimed to identify major constraints and determine the most effective approach to address them. The suggestions were framed by asking open-ended statements to the respondents, and several suggestions were received from the extension personnel. The qualitative data was analysed using the word-cloud generator tool in R software.

RESULTS

The study identified four primary categories of constraints faced by agripreneurs in Table 1. financial constraints, knowledge and skills, personal and social challenges, and psychological constraints. The most significant barrier was the substantial risk involved in establishing agro-based enterprises, with a Rank Based Quotient (RBQ) of 64.44, followed by extensive bank loan procedures (61.11) and high initial capital investment (46.17), which ranked financial constraints as the second most critical challenge with an overall RBQ of 57.24. In terms of knowledge and skills, inadequate technical knowledge regarding agro-based enterprises emerged as the most pressing issue, boasting an RBQ of 70.42, followed by a lack of awareness of key agro-based enterprises (67.67) and an absence of specific training programs (60.11), making this category the highest-ranked constraint with an overall RBQ of 66.07. Personal and social challenges included difficulties in balancing personal and professional lives (55.28), acquiring the expected number of consumers (51.94), and securing family support (52.89), resulting in an overall RBQ of 53.37, which placed it third. Finally, psychological constraints, comprising a lack of decisiveness (50.78), a lack of confidence (49.72), and a negative mindset (48.83), had the lowest overall RBQ score of 49.78, positioning them as the fourth-ranking category.

The overall results indicated that knowledge and skills constraints were the most significant, with the highest RBQ score of 66.07. This highlighted issues such as inadequate technical

Table 1. Constraints faced by Agripreneurs in Southern Odisha

Major Barrier	Constraints	RBQ	Individual Constraint Rank	Mean Overall RBQ Value	Overall Rank
B1 (Financial Constraints)	Huge risk involved in the establishment of the agro-based enterprise.	64.44	III	57.24	II
	The bank loan application process is lengthy and complex	61.11	IV		
	High initial capital investment is required.	46.17	XII		
B2 (Knowledge and Skills Constraints)	Inadequate technical knowledge regarding agro-based enterprise.	70.42	I	66.07	I
	Lack of awareness regarding various key agro-based enterprises.	67.67	II		
	Not received any specific training regarding agro-based enterprise.	60.11	V		
B3 (Personal and Social Constraints)	Problems faced in managing personal life and professional life.	55.28	VI	53.37	III
	Difficult to get the expected number of consumers.	51.94	VIII		
	Lack of support from family.	52.89	VII		
B4 (Psychological Constraints)	Lack of decisiveness to start an agro-based enterprise.	50.78	IX	49.78	IV
	Lack of confidence to succeed in agro-based enterprise.	49.72	X		
	Lack of positive mindset regarding agro-based enterprise.	48.83	XI		

Figure 1. Word Cloud of suggestions perceived by Agripreneurs in South Odisha

knowledge and a lack of awareness about agro-based enterprises. Financial constraints ranked second, with an RBQ score of 57.24, emphasizing challenges like high risks and complicated bank loan procedures. Personal and social constraints came in third, scoring 53.37, which pointed to difficulties in managing a balance between personal and professional life and acquiring consumers. Psychological constraints ranked fourth, with the lowest RBQ score of 49.78. This suggested that while issues related to decisiveness and confidence existed, their impact was less significant than the other constraints.

The suggestions received from agripreneurs highlighted several insights, as seen in the word cloud in Figure 1. Support was the most commonly cited, indicating a widespread need for extensive assistance in several aspects of agro-based business. Financial support emerged as a crucial recommendation, highlighting the need for accessible financial resources to alleviate the considerable risks and huge initial expenditures associated with agro-based firms. Risk mitigation was another critical domain, with recommendations highlighting the formulation of strategies and regulations to alleviate the financial uncertainties and operational risks encountered by agripreneurs. The banking sector was highlighted, indicating the need for enhanced lending processes and more advantageous financing choices customised for agro-based enterprises. The significance of loan accessibility was emphasised, underscoring the need for efficient and facilitative lending procedures. Technology was often recommended, showing the significance of technical breakthroughs and innovations in improving the productivity and sustainability of agricultural enterprises. Expert Advice emerged as a prevalent recommendation, emphasising the need for expert assistance and consultation to assist agripreneurs in navigating the intricacies of the sector and making educated choices.

DISCUSSION

The most significant hurdles were related to knowledge and skills, which emerged as the highest-ranking limitation. This indicated that many agripreneurs lacked the essential technical competence and understanding of major agro-based enterprises, which were crucial for effectively starting and maintaining their operations. Similar results were elucidated by Johari et al., (2024). The scarcity of specialized training further exacerbated this difficulty, pointing to a clear need for tailored educational programs and capacity-building activities to equip prospective agripreneurs with the essential skills and knowledge needed to thrive in the industry. The results were in line with the findings of Agrawal & Jaggi (2024). The substantial risk associated with launching agro-based firms, combined with the complicated and time-consuming bank lending processes, emerged as a key barrier for many agripreneurs. Similar results were reported by Jaiswal et al., (2022).

Personal and social hurdles rated third, indicating that while these concerns were essential, they might not have been as daunting as knowledge and financial constraints. Nettle et al., (2018) mentioned that the challenges of managing personal and professional life, alongside issues related to customer acquisition and lack of family support, highlighted the importance of fostering a healthy social and professional environment for agripreneurs. Mentorship programs, community networks, and access to consumer markets could have significantly alleviated these obstacles. Psychological

restrictions, though ranked fourth, remained crucial issues that required attention. Factors such as indecisiveness, lack of confidence, and a negative mindset could have inhibited Agripreneurs from taking the necessary steps to establish and grow their enterprises. Similar suggestions were found in the study conducted by Janker et al., (2021). This emphasized that psychological support, including mentoring and confidence-building programs, might have promoted a more resilient and optimistic entrepreneurial mentality.

The emphasis on support reflected the need for a comprehensive strategy encompassing financial, technical, and advisory components. Swamy (2016) in his study mentioned that the call for financial assistance underscored the fundamental constraints faced by agro-based enterprises, as early capital needs and high risks necessitated accessible financial instruments tailored to the unique challenges of the industry. Financial institutions were viewed as pivotal in providing specialised credit products and minimising procedural barriers. Risk mitigation techniques, such as insurance products, risk-sharing mechanisms, and supportive policies, were considered essential for safeguarding agripreneurs from financial losses. The focus on banks and loans emphasized a demand for entrepreneur-friendly financial services, advocating for simplified loan processes. Arunkumar et al., (2023) mentioned clear cut indication for tailored plans, polices and strategies for farmers' financial inclusion in their study. These findings partially aligned with the results of Landini & Noussia (2024). The role of technology was emphasised in enhancing efficiency and innovation in agro-processing, marketing, and distribution. Kademani et al., (2024) highlighted in their study the significance of mentoring and professional consulting to assist agripreneurs in navigating challenges and improving business outcomes. Strengthening social networks, mentorship initiatives, and psychological support can foster resilience, while promoting technology adoption and digital tools will improve efficiency and market access. A comprehensive, policy-driven approach is crucial to cultivating a sustainable and thriving agripreneurial ecosystem.

CONCLUSION

The study revealed that agripreneurs in Southern Odisha face numerous challenges, including knowledge and skills, financial, personal, social, and psychological constraints. The most critical barriers are inadequate technical expertise, lack of awareness, and insufficient training. To address these, targeted educational programs and capacity-building initiatives are needed. Financial constraints include high risks, complex loan procedures, and substantial initial capital investments. Personal and social constraints, such as balancing professional and personal life and limited family support, can be addressed through community networks and mentorship programs. Psychological constraints, such as lack of confidence and decisiveness, require interventions like confidence-building and motivational programs. The study recommends comprehensive support systems, financial aid, risk mitigation strategies, access to modern technologies, and expert guidance. Tailored interventions, such as accessible credit schemes and advanced agri-tech integration, can foster a more enabling environment. Future studies should explore crop-specific agripreneurship, digital innovations and climate-resilient strategies to develop targeted and sustainable solutions.

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