

EDITORIAL

Technological innovations being the crucial for enhanced productivity, the farm prices remain a key concern as India fights climate impact. To realize the dream of *Viksit Bharat*, finding business models that make development process more inclusive, rationalization of subsidy and welfare programmes, increased spending of agricultural R&D as well as agricultural extension. With the government focus on infrastructure development, technological advancement and promote exports, India is well positioned to witness agricultural export growth. The overall agricultural credit flow during 2025 is expected to surpass 28 lakh crore rupees. The Australian success in expanding exports has also come through Farm Export Facilitation programme, export hubs, better trade agreements and market access. India needs to accelerate the hybrid technology in pulses and oilseeds to address production deficits, and reduce import burden. The focus must be on meeting the nutrient requirements from crop diversification and breeding for biofortification instead of artificial biofortification as healthy diets are unaffordable for the world's poorest people, and 30% of food produced is lost or wasted. The UN estimates that ending poverty and hunger requires additional financing in agriculture and rural development of \$140 billion per year, of which \$50 billion per year is needed from the private sector, primarily for on-farm and agro-processing investments. There is a \$2 trillion gap in private financing to meet the SDGs and create sustainable, green agricultural value chains.

The current issue (January- March, 2025) contains five research notes, and seventeen full-length research papers. The *full length papers* focused on: Water resources and fisheries production dynamics, students' "communication skill", development of media package, study on SHC, research trend in family farming, home science career aspirations, correlates of agripreneurial competency, performance evaluation of CFLD, drivers of IPM adoption, knowledge towards sustainable agricultural practices, effectiveness of NGO-led livelihood initiatives, impact of crop insurance and employment support, beekeeping knowledge among farmers, climate change adaptation strategies among rural women, adoption of makhana technology, farmers' preference for iari wheat varieties and adoption levels of ipm among vegetable cultivators, whereas, constraints faced by rural youth for opting entrepreneurship as career and by pineapple farmers in adopting climate smart adaptation strategies, usage pattern of ICT tools among university faculty members, training needs assessment of member fish farmers of FFPOs and exploring the strategies, utilization and limitations of digital tool adoption in sugarcane Farming made the '*research note*' section. It continues to be indexed in almost all major databases which includes; SCOPUS, CAB International, AGRIS, Index Copernicus International, Plum X, Medley, SCILIT, UGC-CARE List, Crossref, Semantic Scholar, World Cat, EBSCO, etc. NAAS has given a score of 5.02 for year 2025. The cite score tracker of SCOPUS shows that with steady start of 0.4 (on 05 May, 2024 of 2023) we are at 1.0 on 05 December, 2024. (<https://www.scopus.com/sourceid/21100846015>)

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(Manjeet Singh Nain)

Chief Editor

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Water Resources and Fisheries Production Dynamics for Development of the Fisheries in Sepahijala District of Tripura, India

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HIGHLIGHTS

- A positive and significant relationship between total fish production and water resources in culture and capture fisheries.
- Sonamura and Bishalgarh sub-divisions of the Sepahijala district have the potential to augment the vertical development of fisheries and aquaculture.
- The Jampuijala sub-division has the potential for the horizontal expansion of fisheries and aquaculture.
- Need for identifying stakeholders, conservation, and proper utilisation of the water resources to develop fisheries.

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ABSTRACT

Aquaculture, fisheries, and water resources are important to a region's socioeconomic growth. The study was conducted by using a descriptive research design in all seven blocks of three sub-divisions of the Sepahijala district of Tripurato assess the water resources and utilisation dynamics for fisheries and aquaculture production in the district from the perspective of the development of fisheries in the region. Information regarding the study was based on the cross-sectional and time-series data, collected from the Department of Fisheries, Government of Tripura from 2016-18. The study revealed that culturable water resources were highest in the Sonamura subdivision and lowest in the Jampuijala subdivision. A similar trend was observed in capture fisheries and fish seed production. The study also confirmed the positive and significant relationship between total fish and prawn production in cultural fisheries and culturable water resources; total fish seed production and water were utilised for fish seed production; and between total fish and prawn production from capture fisheries resources with capture fisheries water resources. The study suggested formulating a meticulous strategy by identifying potential stakeholders, assessing availability, conserving, and ensuring proper utilisation of the water resources for the development of the fishers in the district.

INTRODUCTION

Tripura is blessed with both lotic (running) and lentic (standing) rainfed water bodies with an average rainfall of 2100 mm, (DoE&S,

2018). These water bodies improve the landscape's beauty, give recreational opportunities, serve as habitats for wildlife and plants, and have an impact on the climate (Das et al., 2024). However, the water holding capacity of the water bodies in Tripura is poor. Most

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of the soils in Tripura are red lateritic and acidic (Saha et al., 2017). The water area of Tripura is 34,416.94 ha, comprised of lakes, rivers, tanks, ponds, reservoirs, etc., of which only 26,534.18 ha is used for fishing (DoE&S, 2018). The rivers Gomati (249 million cubic meters), Manu (170 mcm), and Khowai (115 mcm) carry almost 67.5 per cent of Tripura's total flow. However, 32.5 per cent of the total surface flow is carried by other rivers (ENVIS Centre: Tripura, 2013).

The culture fisheries resources and aquaculture plays a significant role in the region's socioeconomic development (FAO, 2022). Aquaculture is important both in terms of its contribution to the economy and human nutrition (Sajeev et al., 2023). It also creates a great opportunity for employment in any region (NFDB, 2018). One of the most important sources of many aquatic species, particularly fish, is freshwater bodies. Fish is arguably vital for human nutrition (Saikia et al., 2024; Patra et al., 2017). Natural breeding grounds for fish and most of the other aquatic animals heavily depend on water resources (FAO, 2020). Thus, it is necessary to have a clear understanding of water resources in any location for sustainable fisheries and aquaculture through better management and to develop a proper strategy for the socioeconomic development of the fisheries in the region (Mir et al., 2023; Sarkar et al., 2022). In this subset, this study aims to assess the water resources and utilisation dynamics for fisheries and aquaculture production in the Sepahijala district from the perspective of the development of the fisheries in the region.

METHODOLOGY

Tripura is located in the northeastern part of India, bordered to the north, west, south, and southeast by Bangladesh and the east by Assam and Mizoram states of India. It is situated between latitudes 22°57'N and 24°33'N and longitudes 91°10'E and 92°20'E (ENVIS Centre: Tripura, 2013). This study was conducted in a descriptive research design in the Sepahijala district of Tripura. The total area of the district is 1043.04 km², and the total population is 5,42,731 (Govt. of Tripura, 2023). The Sepahijala district of Tripura, with a total area of 1043.58 km², is one of the recently established districts in the state. The Baramura's minor hilly ranges are primarily within the Jampuijala Sub-Division and only cover around 12% of the district. There are 520.97 km² areas of the river, 39.33 km² of the rivulet, 67 ha of barrage and 100 ha of the lake in the Sepahijala district (DoE&S, 2018). The main water resources of Sepahijala district are comprised of the Gomati and Bijoy rivers. In addition, nearly all fish farmers (96%) do not have a reliable source of water for their fish ponds other than precipitation, and most of the fish farmers (88%) have seasonal ponds (Shil et al., 2022). The Gomati River has the largest basin of any river in Tripura, with 132 km² of its 2,492 km² catchment area located in the Sonamura subdivision of the Sepahijala district (Das et al., 2024).

All seven blocks of the three subdivisions in the Sepahijala district of Tripura were the locale of this study. The cross-sectional and time series data gathered from the Department of Fisheries, Government of Tripura, from 2016 to 2018 served as the basis for the study's information. Cross-sectional data at the block level were used to analyse the status of water resources of the Sepahijala

district, and time-series data were utilised for accurate projection of fish production. The collected data were analysed and interpreted to draw a logical conclusion using descriptive statistics (frequency, mean, and standard deviation), Spearman's correlation analysis, and graphical representation.

RESULTS

Water resources and culture fisheries production dynamics in Sepahijala district in 2017-18

The study unfolds that the available water resources of the Sepahijala district were 3824.96 ha, comprised of 28514 water bodies such as ponds and tanks, mini barrages, rivers, rivulets, and lakes, under culture and capture fishery resources. It could be observed from Table 1 that the total number of culturable water bodies (ponds/tanks, mini barrages and others) was the highest in the Sonamura sub-division with 14302 water bodies, whereas 8640 and 5572 water bodies were recorded at Bishalgarh and Jampuijala sub-divisions, respectively. In terms of the area of water bodies, Sonamura, Bishalgarh, and Jampuijala sub-divisions comprised 1841.86 ha, 1150.13 ha, and 832.97 ha water areas, respectively.

Table 1 also ascertains that total fish and prawn production from culture fisheries resources was highest in the Sonamura sub-division (4691.09 MT), as culturable water resources were maximum in this sub-division (1841.86 ha). Sonamura sub-division was followed by Bishalgarh (3029.22 MT) and Jampuijala (1986.97 MT) sub-divisions in total fish and prawn production from culture fisheries resources. The same trend was also found in the case of total fish seed production. But, fish seed production in Jampuijala was abysmally low at 11.1 Lakh as only 1.64 ha water area was utilised for fish seed production in this sub-division. The Nalchar block produced the highest amount of fish seeds (175.97 Lakh), which was followed by the Bishalgarh block (89.9 Lakh) because of maximum water areas (11.6 ha and 6.15 ha in Nalchar and Bishalgarh, respectively) utilised for fish seed production among the all the blocks. The total fish seed production in the Sepahijala district was 441.94 Lakh, as evident from Table 1.

New water bodies made during 2016-18

The result presented in Table 2 shows that 55.79 ha, 60.49 ha, and 27.1 ha new areas were made for fisheries in the Jampuijala, Sonamura, and Bishalgarh subdivisions, respectively in 2017-18. It is observed from Table 2 that the maximum percentage (7.18%) of increase in water bodies for fisheries was achieved in the Jampuijala subdivision. Block-wise data of newly made water bodies are also presented in Table 2 shows that during 2017-18, no new water body was made in Bishalgarh Municipal Corporation (M.C) and Sonamura Nagar Panchayat (N.P.) whereas, the maximum number of water bodies were made at Jampuijala and under Kathalia block of Sonamura sub-division, as the Jampuijala sub-division lagged in terms of the number of fish culturable water resources, as shown in Table 1.

Division-wise water bodies made by different agencies

It is visible from Figure 1 that the contribution of Government agencies was more in the making of new water bodies in the

Table 1. Culturable water resources of Sepahijala district in 2017-18

Subdivision	Block	Culturable Water Resources						Fish and Fish Seed Production in Culture Fisheries				
		Ponds/Tanks		Minibarrage		Others		Total		Total Fish and Prawn Production from Culture Fisheries (MT)	Water Area Utilised for Fish Seed Production (ha)	Total Seed Production (Lakh)
		Nos. of water bodies	Area of water bodies (ha)	Nos. of water bodies	Area of water bodies (ha)	Nos. of water bodies	Area of water bodies (ha)	Nos. of water bodies	Area of water bodies (ha)			
Bishalgarh Sub-division	Bishalgarh	5293.00	628.71	137.00	31.23	107.00	33.69	5537.00	693.63	1751.35	6.15	89.90
	Charilam	2890.00	391.92	190.00	58.12	23.00	6.46	3103.00	456.50	1277.87	1.82	21.00
Jampuijala Sub-Division	Jampuijala	4102.00	556.00	1468.00	276.77	2.00	0.20	5572.00	832.97	1986.97	1.64	11.10
Sonamura Sub-Division	Sonamura N. P	202.00	22.70	0.00	0.00	0.00	0.00	202.00	22.70	57.57	0.96	8.75
	Melaghar M.C	492.00	93.43	0.00	0.00	0.00	0.00	492.00	93.43	274.24	1.6	55.00
	Nalchar	3862.00	455.97	150.00	28.85	0.00	0.00	4012.00	484.82	1162.55	11.6	175.95
	Mohanbhog	1787.00	284.37	502.00	89.31	4.00	0.44	2293.00	374.12	986.44	4.62	40.50
	Boxanagar	2756.00	302.73	502.00	92.46	10.00	2.28	3268.00	397.47	1091.95	0.62	2.74
	Kathalia	3615.00	379.00	420.00	90.32	0.00	0.00	4035.00	469.32	1118.34	3.28	37.00
Total		24999	3114.83	3369	667.06	146	43.07	28514	3824.96	9707.26	32.29	441.94

MC- Municipal Corporation, NP- Nagar Panchayat

Sepahijala district compared to private agencies. In the case of sub-division-wise data (Figure 1), it was observed that 55.79% and 42.51% of new water bodies were made by Government agencies in Jampuijala and Sonamura sub-divisions, respectively during 2017-18, whereas only 13.93% and 17.98% of water bodies were made by the private sector in Bishalgarh and Sonamura Sub-divisions, respectively. However, no water body was made by the private sector in the Jampuijala sub-division.

Capture fisheries water resources of the Sepahijala district

There were 727.3 ha of capture fisheries water resources available in the Sepahijala district, comprising rivers, rivulets, barrages, and lakes. The rivers occupied the largest water areas (520.97 ha) compared to other capture fisheries water resources, as evidenced by Table 3. The Sonamura sub-division (414.97 ha) had more capture fisheries water resources than those other sub-divisions. It was observed in block-wise distribution that the Melaghar block had the largest (150.72 ha) water area available for capture fisheries.

Sector-wise utilisation of water resources for fisheries

The average of the sector-wise utilisation of water resources for fisheries was calculated and presented in Table 4. It was visible from Table 4 that the majority of the utilisation of water resources for fisheries was done privately by the fishers or other private sectors, with an average of 368.40 ha, followed by the Government sector with only 10.82 ha on average. But, a very negligible contribution was seen from SHGs (1.06 ha) and Cooperative societies (1.58 ha). The highest participation from the private sector was observed from the Sonamura sub-division, as fisheries and aquaculture are very popular among the progressive fish farmers in this sub-division.

The relationship between water resources and production parameters in fisheries in the Sepahijala district was measured by Pearson’s correlation coefficient, and presented in Table5. Results suggest that Total fish and prawn production from culture fisheries resources was positively and significantly correlated with culturable water resources at the 1% level of significance (Das, 2019). Similarly, total fish seed production was positively and significantly correlated with the water area utilised for fish seed production at the 1% level of significance. In the case of capture fisheries in the Sepahijala district, total fish and prawn production from capture fisheries resources were positively and significantly correlated with capture fisheries water resources at the 5% level of significance (Chutia et al., 2018).

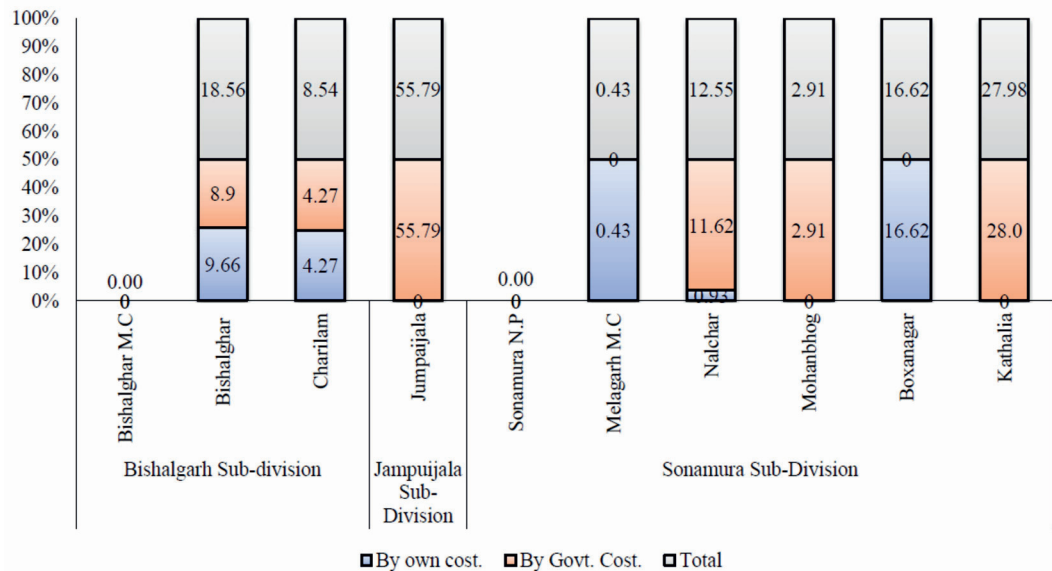
DISCUSSION

The results of the study help enlighten the different aspects of water resource utilisation and its relation with fisheries production in the study area. The state of Tripura is primarily fish-consuming, and its supply cannot keep up with the state’s rising demand (Shil et al., 2022). Sepahijala district can play an important role in meeting the increasing demand of the state because of the productive water resources of the district. Water resource assessment of Sepahijala district helps identify different water resource availability, conservation, and proper utilisation of the

Table 2. Growth in new water bodies made during 2016-18

Subdivision	Block	TWBM*-2017-18	TWB*-2016-17	% Growth in New Water Bodies Made
Bishalgarh Sub-division	Bishalgarh M.C	0.00	50.86	0.00%
	Bishalgarh	18.56	631.6	2.94%
	Charilam	8.54	447.96	1.91%
Jampuijala Sub-Division	Jampuijala	55.79	777.18	7.18%
Sonamura Sub-Division	Sonamura N.P	0.00	22.7	0.00%
	Melagarh M.C	0.43	93	0.46%
	Nalchar	12.55	476.79	2.63%
	Mohanbhog	2.91	371.21	0.78%
	Boxanagar	16.62	381.85	4.35%
	Kathalia	27.98	443.44	6.31%
Total		143.38	3696.59	3.88%

*TWBM-Total water body made; TWB- Total water body, MC- Municipal Corporation, NP- Nagar Panchayat

Figure 1. Sub-division wise new waterbodies made by different agencies**Table 3.** Different types capture fisheries water resources of Sepahijala district

Subdivision	Block	River	Rivulet	Barrage	Lake	Total Area of capture resources (ha)	Average	SD	SE
Bishalgarh Sub-division	Bishalgarh	108.93	6.64	0.00	0.00	115.57	28.89	53.45	30.86
	Charilam	93.10	10.50	0.00	0.00	103.60	25.90	45.07	26.02
Jampuijala Sub-Division	Jampuijala	70.97	22.19	0.00	0.00	93.16	23.29	33.46	19.32
Sonamura Sub-Division	Sonamura	10.00	0.00	0.00	0.00	10.00	2.50	5.00	2.89
	Melagarh	50.72	0.00	0.00	100.00	150.72	37.68	47.94	27.68
	Nalchar	15.02	0.00	51.80	0.00	66.82	16.71	24.44	14.11
	Mohanbhog	142.01	0.00	0.00	0.00	142.01	35.50	71.01	40.99
	Boxanagar	24.22	0.00	0.00	0.00	24.22	6.06	12.11	6.99
	Kathalia	6.00	0.00	15.20	0.00	21.20	5.30	7.18	4.15
Total		520.97	39.33	67.00	100.00	727.3	-	-	-

water resources concerning sustainable fisheries and aquaculture in the region (Biswas, 2008). Culturable water resources are more in the Sonamura subdivision due to the presence of the Gomati River basin in the sub-division. A similar scenario is also found in the

case of capture fisheries and fish seed production. The study also establishes the positive and significant relationship between total fish and prawn production in cultural fisheries and culturable water resources; total fish seed production and water area utilised for fish

Table 4. Sector-wise utilisation of water resources for fisheries

Division	Subdivision/Block	Private (ha)	Cooperatives (ha)	SHG (ha)	Government (ha)
Bishalgarh Sub-division	Bishalgarh M.C	45.17	0.00	0.00	0.98
	Bishalgarh	613.41	0.00	3.48	28.51
	Charilam	433.84	0.00	4.52	17.42
Jampuijala Sub-Division	Jampuijala	803.65	0.00	1.72	27.60
Sonamura Sub-Division	Sonamura	20.30	1.28	0.00	1.12
	Melaghar	90.30	2.25	0.64	0.24
	Nalchar	476.63	3.50	0.92	3.39
	Mohanbhog	368.00	3.52	0.48	1.88
	Boxanagar	390.87	0.00	1.04	3.20
	Kathalia	441.84	0.00	3.04	23.84
Average		368.40	1.06	1.58	10.82
SD		252.62	1.50	1.57	12.04
Min		20.30	0.00	0.00	0.24
Max		803.65	3.52	4.52	28.51
Median		412.36	0.00	0.98	3.30

Table 5. Relationship among water resources and production in fisheries in Sepahijala district

Parameters	Culturable Water Resources	Capture Fisheries Water Resources	Total Fish and Prawn Production from Culture Fisheries Resources	Total Fish and Prawn Production from Capture Fisheries Resources	Water Area Utilised for Fish Seed Production	Total Fish Seed Production
Culturable Water Resources	1	0.243	0.994**	0.407	0.362	0.241
Capture Fisheries Water Resources	0.243	1	0.337	0.702*	0.118	0.392
Total Fish and Prawn Production from Culture Fisheries Resources	0.994**	0.337	1	0.484	0.338	0.217
Total Fish and Prawn Production from Capture Fisheries Resources	0.407	0.702*	0.484	1	0.073	0.227
Water Area Utilised for Fish Seed Production	0.362	0.118	0.338	0.073	1	0.959
Total Fish Seed Production	0.241	0.392	0.217	0.227	0.959**	1

* 5% level of significance, ** 1% level of significance

seed production; and between total fish and prawn production from capture fisheries resources with capture fisheries water resources (Chutia et al., 2018; FAO, 2024). Hence, the Sonamura sub-division of the Sepahijala district has the potential to augment the vertical development of fisheries and aquaculture, which needs efficient and sustainable utilisation of water resources.

On the contrary, the Jampuijala sub-division lags in terms of fisheries and aquaculture activities due to relatively lesser water resources available, hilly terrain, a higher percentage of tradition-bound fish farmers, lack of innovativeness among the fish farming communities. These are evidenced by the lesser involvement of fish farmers and private sectors in the making of new water resources for the horizontal expansion of fisheries and aquaculture in the subdivision. However, the Government sector has made a serious attempt in this regard (Nirmalkar et al., 2022), which is evidenced by the quantum jump (7.18%) in the making of new water resources in the subdivision in 2017-18 over the base year 2016-17. Thus, the Jampuijala sub-division provides scope for the horizontal expansion of fisheries and aquaculture in the district.

CONCLUSION

Water resource mapping of the Sepahijala district reveals the fact that the Sepahijala district of Tripura has the potential relation

to sustainable fisheries and aquaculture in the region. The sub-division-wise analysis suggests that the Sonamura and Bishalgarh sub-divisions of the district have the potential to augment vertical development whereas, the Jampuijala sub-division has the potential for the horizontal expansion of fisheries and aquaculture in the district. Hence, a meticulous strategy formulation is needed by identifying potential stakeholders, water resource availability, conservation and proper utilisation of the water resources for target-oriented horizontal and vertical development to augment sustainable fisheries and aquaculture in the region.

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Students' "Communication skill" Training Preferences at Dr. Rajendra Prasad Central Agricultural University, India

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HIGHLIGHTS

- Professional communication skills are one of the major requirements in today's world for placement in public or private sector.
- The students (future job aspirants) preferred the short and intensive communication skills development training program organized at the college/university premises.
- The students preferred the industry professionals or HR experts as the trainers of the future training programs.
- The students indicated that they would prefer small group of participants during the training.

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ABSTRACT

The study attempted to explore the preferences of the students enrolled in a Central Agricultural University of India (Dr. Rajendra Prasad Central Agricultural University) regarding future communication skills training programs from their placement point during 2024. Soft skills (especially the professional communication skills) have become one of the mandatory criteria for placement in contemporary India. It is quite insufficient to secure a job only based on the hard skills or knowledge as achieved throughout the degree program. This issue has received a tremendous attention by the different educational institutions in agriculture and allied sectors. 100 students from RPCAU were the respondents of this study, and they were asked to indicate their preferences regarding the future professional communication skills training sessions as conducted by the university's placement cell. The students indicated their preferences regarding content, venue and duration of the future trainings, training participants' size, time of the trainings, various methods used during those trainings, trainer types etc. The comprehensive view of the students' preferences regarding the future soft skills trainings and this research study will be highly beneficial for the university administrators to sketch out the roadmap for future professional skills development trainings for the university students.

INTRODUCTION

Students are the most viable and lively section of population irrespective of any nation and the progress as well as upliftment of students would duly determine the progress of a community or a nation (Meinam et al., 2023). It is observed that most of the training conducted are not based on participatory need assessment, instead major focuses remains on the coverage of training curriculum

(Arunkumar et al., 2021). But the unemployment amongst the youths across the globe is becoming a vital issue in this current century, and it is mostly attributed to the lack of required skill sets amongst the new college graduates. The employers in the modern world are not only interested in the academic achievement and hard knowledge of the university or college graduates, but they are also significantly looking for generic skills or "soft skills" of the job aspirants (Ahmad, 2012). The university graduates, who are mostly

the job seekers, are the applicants for different types of jobs. Those fresh graduates are gaining hard knowledge of various disciplines through the course of their study at a college or university, but there was less focus on the “soft skills” development of the college students, particularly in India and other south Asian countries (Chithra, 2013; Bharathi, 2016). Indian agricultural universities and their constituent colleges are not an exception as well. As the employers in the current time are significantly emphasizing the needs of “soft skills” amongst the job applicants or college graduates, the educational institutions including colleges and universities are considering the inclusion of “soft skills” development training or courses in the curriculum (Cleland et al., 2005).

The students at various agricultural universities in India previously applied as well as were selected in various public sector jobs and “soft skills” were rarely considered in those jobs. But currently, the gradual emphasis of “soft skills” in the selection process has pushed the job aspirants to become sufficiently strong in soft skills. Various employers and executives emphasized “communication skills” as the fundamentally important soft skill apart from integrity of the job seekers or candidates (Ihmeideh et al., 2010; Arunachalam et al., 2020). Stephenson et al., (2015) indicated that persons with strong interpersonal skills will always be preferred much by the employers across various disciplines. In the job-seeking process, the professional communication skills play a vital role, and the candidates get tested by the employers during the recruitment process. It was found that one in five employers globally cannot recruit new candidates as the candidates have significant deficit of various soft skills including the interpersonal communication skills (Manpower Group, 2013). There is a requirement of generating as well as introducing special courses for the undergraduate students, so that they can learn and gain some practical experiences of professional communication skills (Robles, 2012). So, the colleges and universities in the contemporary world are focusing in introducing additional professional development courses and training programs to improve the professional communication skills of the students. Understanding the students’ preferences regarding the future training sessions is important in order to elevate the degree of students’ participation in those training sessions. This research study tried to investigate the preferences of the enrolled students at Dr. Rajendra Prasad Central Agricultural University (RPCAU) regarding such future training programs.

METHODOLOGY

Dr. Rajendra Prasad Central Agricultural University (RPCAU) which is one of the 3 central agricultural universities in India was selected purposively for this research study. Dr. Rajendra Prasad Central Agricultural University is a premier agricultural education institution in India with a strong base of students from different Indian states and abroad as well. This institution and the location “Pusa” also possess a rich historical background since British colonial period. RPCAU was chosen purposively for this study because the researchers were closely connected with RPCAU, and it is also a prestigious “*Institute of National Importance*” as declared by Govt. of India previously.

The principal objective of this research study was to gather and understand the suggestions or preference of the university students enrolled at RPCAU, Pusa regarding the future professional communication or soft skills-based training workshops/programs organized by RPCAU. A stratified random sampling method, which is a probability sampling technique, was used to select 100 students from Dr. Rajendra Prasad Central Agricultural University, including Undergraduate, Master’s, and PhD students. Here the total no. of respondents is 100 as selected from RPCAU. This study used *ex-post facto* research design. To gather personal suggestions on various aspects related to the organization of future training programs for enhancing professional communication skills, a survey instrument was used, and the data were collected in-person from the student respondents. The pre-tested interview schedule (*i.e.* the survey instrument) was used to collect the data from 100 respondents and the face/content validity was assessed beforehand by the experienced faculty members of Department of Extension Education. These training programs are expected to significantly improve students’ competence and suitability for future placements. Based on students’ suggestions and preferences, upcoming training sessions will be organized in a way that encourages spontaneous participation from most RPCAU students, allowing them to fully benefit from these opportunities.

Suggestions were gathered from the respondents on eight specific aspects of the training, including training methods, the training contents, training venue, group size, duration, timing, trainer’s types, and post-training support for the trainees by university’s placement division. There were several items under each of these broad areas and the respondents indicated their preferences for each of those items under each area. The responses were collected using an instrument having continuum of 4 points *i.e.* Most, moderate, less, not and the collected responses were screened, analyzed as well as segregated quantitatively using descriptive statistical tools thoroughly. Finally, the components of these 8 aspects of communication skills training are ranked based on he calculated weighted mean score. Score 4 was assigned for the “Most” responses, followed by score 3 for “Moderate” responses, score 2 for “Less” responses and score 1 for “Not” responses. Thus, the weighted mean score was calculated for each alternative under all the 8 aspects of a future skill development training. The above statistical analysis of the collected data was performed using SPSS software (v. 26). It helped the researchers to obtain a transparent view about the students’ preferences or suggestions about the future professional communication skills or other soft skills development training programs organized by RPCAU, Pusa.

RESULTS

The student respondents indicated their suggestions on the contents of the future communication skills improvement training programs organized by RPCAU, Pusa. The four key components of communication skills considered were group discussion, personal interviews, writing skills and public speaking. The students’ training content priorities revealed that over 50 per cent of respondents indicated a strong preference for training in public speaking, group discussions, and personal interviews. Fewer than half prioritized writing skill improvement as their top choice. Additionally, the data

shows that nearly all students expressed a preference for training in all four areas, either to a great or moderate extent (Table 1). Notably, the preferred order for organizing the training program is personal interviews first, followed by group discussions, public speaking, and writing skills. Additionally, student respondents were asked to provide suggestions regarding the venue for future training programs aimed at enhancing their professional communication skills. The venue options included locations within the university campus, private training institutes, agricultural research institutes, public training institutes, and university classrooms. A strong preference for holding training programs on the university campus (DRPCAU campus) was expressed by 78 per cent of respondents. Of these, 62 per cent preferred their classrooms, 55 per cent favored an agricultural research institute, 30 per cent opted for a private training institute, and 27 per cent chose a public training institute (Table 1). Notably, 24 per cent of respondents indicated a lower preference for private training institutes. The respondents clearly indicated that the university campus should be the top choice for organizing these types of training programs.

The students were asked about their suggestions on the length of the future training programs. The alternatives of the program durations as provided were 2 days training, 3 days training, 1 day training, 2 weeks training, 1 week training, and above 2 weeks training

session. Thirty-six percent of students showed a strong preference for a one-week training duration, followed by 32 per cent for two weeks, 31 per cent for two days, 30 per cent for more than two weeks, 25 per cent for three days, and 21 per cent for a one-day program. Conversely, 37 per cent of respondents expressed a complete lack of preference for training programs lasting more than two weeks (Table 2). The students' preferences suggest that they favor training programs that are neither too short, like a one-day session, nor too long, exceeding two weeks. It is important to consider this when organizing training programs to ensure high student participation. Overall, the data indicates that most students prefer training programs aimed at improving communication skills to last between three days and one week. Respondents were asked to provide suggestions regarding the ideal group size for training programs aimed at improving their communication skills. The different options of the size of the participants groups were up to 80-100 students, 40-60 students, 20 students, 60-80 students, 20-40 students, and more than 100 students. Seventy-eight percent of students expressed a strong preference for participant groups of 20 or fewer, followed by 28 per cent who preferred groups of 20-40 students. Larger group sizes, such as 40-60, 60-80, or 80-100 students, were favored by only a small number of students, making these preferences negligible. Additionally, 84 per cent of respondents

Table 1. Distribution of respondents as per their suggestion/preference of the future training contents and venue

S.No.	Contents of training	Respondents' Preference(frequency/percentage)				Weighted Mean Score	Rank
		Most	Moderate	Less	Not		
1.	Personal Interview	69(69%)	25(25%)	5(5%)	1(1%)	90.50	I
2.	Group Discussion	51(51%)	39(39%)	9(9%)	1(1%)	85.00	III
3.	Public Speaking	54(54%)	37(37%)	8(8%)	1(1%)	86.00	II
4.	Writing Skills	33(33%)	48(48%)	18(18%)	1(1%)	78.25	IV
	Venue of the training						
1.	Agricultural research institute	55(55%)	39(39%)	5(5%)	1(1%)	87.00	II
2.	Public training institute	27(27%)	63(63%)	9(9%)	1(1%)	79.00	IV
3.	In the university/college classrooms	62(62%)	21(21%)	15(15%)	2(2%)	85.75	III
4.	University/college campus	78(78%)	17(17%)	5(5%)	0(0%)	93.25	I
5.	Private training institute	30(30%)	41(41%)	24(24%)	5(5%)	74.00	V

Table 2. Distribution of respondents according to their suggestion/preference regarding the training programs' duration or length and size of the participant groups in training

S.No.	Length of the training program	Respondents' Preference (frequency/percentage)				Weighted Mean Score	Rank
		Most	Moderate	Less	Not		
1.	1 week training	36(36%)	41(41%)	21(21%)	2(2%)	77.75	I
2.	2 days training	31(31%)	28(28%)	29(29%)	12(12%)	69.50	III
3.	2 weeks training	32(32%)	27(27%)	31(31%)	10(10%)	70.25	II
4.	1 day training	21(21%)	34(34%)	24(24%)	21(21%)	63.75	IV
5.	3 days training	25(25%)	50(50%)	20(20%)	5(5%)	77.75	I
6.	More than 2 weeks training	30(30%)	15(15%)	18(18%)	37(37%)	59.50	V
	Size of the participant groups						
1.	40-60 students	6(6%)	47(47%)	38(38%)	9(9%)	62.50	III
2.	20-40 students	25(25%)	66(66%)	4(4%)	5(5%)	77.75	II
3.	Up to 20 students	78(78%)	11(11%)	7(7%)	4(4%)	90.75	I
4.	More than 100 students	2(2%)	4(4%)	10(10%)	84(84%)	31.00	VI
5.	80-100 students	7(7%)	4(4%)	25(25%)	64(64%)	38.50	V
6.	60-80 students	5(5%)	8(8%)	59(59%)	28(28%)	52.50	IV

were strongly opposed to groups larger than 100, with 64 per cent disfavoring groups of 80-100 students (Table 2). Overall, the data suggests that students overwhelmingly prefer smaller participant groups. Therefore, when organizing training programs, it is important to limit group sizes to 20 students, with an upper limit of 40 in special cases.

The respondents also shared their preferences regarding the training methods used to improve communication skills from a placement point of view. The options of the “methods used in the training programs” were case studies, lecture, activity, demonstration, group discussions, simulation, role playing and panel discussion. Seventy-six percent of students showed a strong preference for activities as a method used in training programs, followed by 70 per cent for demonstrations, 65 per cent for group discussions, and 60 per cent for both case studies and role-playing. Fifty-two percent favored simulations, while only 23 per cent preferred lectures, marking it as the least favored method (Table 3). The analysis indicates that students generally preferred most methods but leaned more towards activities, demonstrations, and similar approaches, while lectures were less favored. Therefore, it is important to prioritize methods like activities and demonstrations over lectures, while ensuring a balanced inclusion of all the mentioned methods in the training. The preferences of the students were also sought for the time of conducting such future training programs

and the options of the timings for future training programs were after the midterm exam, after the end term exam, the beginning of the academic year, and just before the completion of the degree program. Fifty-six percent of students expressed the strongest preference for having the training sessions arranged at the starting of the college academic session, with an equal percentage favoring the period just before completing their degree program (Table 3). Significantly fewer students preferred the program to be held after the mid-term or end-term exams, with these options receiving moderate support. Based on the overall data, it is recommended that the university should organize training programs either at the start of the academic session or right before students complete their degree program.

The students were also asked for their preferences on the trainers’ types invited in the future university organized trainings. Different options of the trainer’s types in the training programs were the resource persons from industry, faculty members of the university, HR experts and senior students/alumni. Seventy-four percent of students strongly preferred HR experts as trainers, followed by 67 per cent who favored industry-based resource persons, and 42 per cent who preferred senior students or alumni (Table 4). The data indicates that students showed less preference for university faculty members as trainers. Therefore, it is recommended that the university administration should invite HR

Table 3. Distribution of respondents according to their suggestion/preference regarding the communication skills training methods

S.No.	Methods used in the training	Respondents’ Preference (frequency/percentage)				Weighted Mean Score	Rank
		Most	Moderate	Less	Not		
1.	Group Discussion	65(65%)	30(30%)	5(5%)	0(0%)	90.00	III
2.	Activity	76(76%)	19(19%)	5(5%)	0(0%)	92.75	I
3.	Case studies	60(60%)	35(35%)	5(5%)	0(0%)	88.75	IV
4.	Lecture	23(23%)	38(38%)	32(32%)	7(7%)	69.25	VII
5.	Demonstration	70(70%)	26(26%)	4(4%)	0(0%)	91.50	II
6.	Role playing	60(60%)	35(35%)	5(5%)	0(0%)	88.75	IV
7.	Simulation	52(52%)	37(37%)	10(10%)	1(1%)	85.00	V
8.	Panel Discussion	32(32%)	55(55%)	11(11%)	2(2%)	79.25	VI
Time of organising training							
1.	At the starting of the academic year	57(57%)	21(21%)	14(14%)	8(8%)	81.75	I
2.	Before the completion of the degree program	56(56%)	19(19%)	13(13%)	12(12%)	79.75	II
3.	Post end term exam	32(32%)	37(37%)	21(21%)	10(10%)	72.75	IV
4.	Post midterm exam	30(30%)	49(49%)	12(12%)	9(9%)	75.00	III

Table 4. Suggestion/preference regarding the type of trainers involved in future training programs and the type of supports provided by the Placement cell in the post-training period

S.No.	Type of trainers involved in training programs	Respondents’ Preference (frequency/percentage)				Weighted Mean Score	Rank
		Most	Moderate	Less	Not		
1.	Resource persons from industry	67(67%)	27(27%)	5(5%)	1(1%)	90.00	II
2.	Faculty members of the university	25(25%)	41(41%)	31(31%)	3(3%)	72.00	IV
3.	HR experts	74(74%)	20(20%)	5(5%)	1(1%)	91.75	I
4.	Senior students/Alumni	42(42%)	47(47%)	11(11%)	0(0%)	82.75	III
Type of supports provided by the Placement cell after the training programs							
1.	Individual counselling	68(68%)	21(21%)	9(9%)	2(2%)	88.75	II
2.	Provision of ppts	34(34%)	54(54%)	10(10%)	2(2%)	80.00	IV
3.	CDs/Digital materials	35(35%)	55(55%)	8(8%)	2(2%)	80.75	III
4.	Provision of notes	32(32%)	48(48%)	17(17%)	3(3%)	77.25	V
5.	Time to time meeting	71(71%)	23(23%)	4(4%)	2(2%)	90.75	I

experts and industry professionals from reputable institutions or organizations to lead the training programs. Finally, the student respondents were also asked about their preference on the post-training support offered by the RPCAU Placement cell and few options were included like provision of notes, time to time meeting, provision of ppts, CDs/Digital materials and individual counselling. Seventy-one percent of students strongly preferred regular meetings, followed by 68 per cent who favored individual counseling, while fewer respondents notably preferred resources like notes, presentations, CDs, or other digital materials (Table 4). The overall data indicates that students predominantly valued regular meetings and individual counseling. Therefore, when organizing training programs, it is important for the organizers to emphasize these two types of support during the post-training period, in line with students' suggestions.

DISCUSSION

Though the agricultural graduates in India used to have several job availabilities even a few years back, the scenario is getting changed in the contemporary period and there is a growing job crisis for the agricultural graduates too (Arunachalam, 2020). The agriculture and allied sciences graduates are struggling to secure quality jobs currently. There is also a significant increase of the private sectors employers in providing employment to the agriculture graduates. The agricultural university graduates in India are also facing some issues of unemployment or lack of required skills in the current period. Many students in the Indian agricultural universities are having a rural background and they have a significant lacunae of professional communication skills as required for the industry (Hari et al., 2022). It was found in a survey in the United States that 75% of the employers hold a strong opinion that the degree offering institutions like colleges and universities should prioritize the oral as well as written communication skills development training for the enrolled students (Association of American Colleges and Universities, 2013). Conducting multiple training sessions by the proper division of the colleges and universities are significantly beneficial towards teaching communication skills to the future job aspirants and that will eventually provide experiential knowledge to the students (Wagner et al., 2002). Arranging proper training on professional skills and soft skills development will be beneficial for the students to adopt the proper communication skills (Anderson, 2014; Bell et al., 2014; Harlak et al., 2008). Ihmeideh et al., (2010) & Cleland et al., (2005) indicated in their studies that having a positive communication environment is quite beneficial to promote a better learning of professional communication skills amongst the students. It is notable that conducting professional communication skills training at a college or university comprises several factors. There are several factors which the organizers or institutions should consider while planning for a future communication skills or soft skills development training like training methods, the training contents, training venue, group size, duration, timing, trainer types, and the post-training support provided by university's Placement Cell etc. The placement cell or the RPCAU administration should understand the perspective of the students to make such training programs successful.

The appropriate training of person can improve process as well as product (Nain & Trikha, 2009), it was quite prominent from the findings that all the contents of professional communication skills training are essential, but the students emphasized the area of personal interview training to be included in the future training sessions. Nearly about 70 per cent of the respondents indicated that personal interview should be a focus of the future trainings. Majority of the student respondents had a preference of having the future trainings inside the college or university premises. This is unexceptionally valid as the students do not spend their own money as well as time to travel far due to such professional development training. The participation of the students will also be more if the training is conducted on campus. The training should vary from 1-3 days, and it should not exceed a week of timeline. Some techniques like activity, group discussion, demonstration etc. should definitely be a part of the future training programs. Students preferred small sized participants group for training as it will be much more convenient for them to get involved in the training program proactively. Besides, the students indicated their greater preference for the industry resource persons or HR professionals from various companies to be invited as the lead trainers for future soft skills or professional communication skills training. These prior assessments will also be beneficial to prepare a training module for the continuing students or the future job seekers.

CONCLUSION

It was found that the university students mostly preferred future training on personal job interviews, university or college campus as the venue of future training programs, 1-3 days as the duration of the future trainings. Besides, it was also found that students indicated their highest preference for activity or practical ways of training as the future training method. Students also suggested to organize such future training programs on improving professional communication skills at the beginning of the academic year or before the completion of their degree programs. They primarily suggested to invite various HR experts and industry resource persons during the future training programs etc. This study helps the Indian agricultural universities and the respective placement cells to reconfigure as well as restructure their mode of actions in terms of planning for future workshops or training sessions for soft skills (or professional communication skills development) of the future job aspirants having an academic background in agriculture and allied sectors.

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Development of Media Package for Creating Awareness among Rural Women Regarding use of Aloe vera

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HIGHLIGHTS

- Media package regarding health benefit, its nutritive value and usage of Aloe Vera into different forms for curing various ailments was developed.
- Awareness to rural women regarding various parameters of Aloe Vera was disseminated through developed media package.
- Difference in mean scores obtained from pre and post exposure indicated that the respondents had gained awareness regarding all parameters of Aloe vera.

ARTICLE INFO

Keywords: Media package, Aloe vera plant, Awareness level, Printed material, WhatsApp message.

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ABSTRACT

To check the effectiveness of developed media package on Aloe vera, a sample of 130 rural women from 13 villages of Ludhiana district was purposively selected. The data were collected in April and May 2024 from Ludhiana district and were analyzed with the help of percentage, mean score and paired t-test. The media package containing printed material, WhatsApp messages and video clips on Aloe vera was developed and validated by 30 Subject Matter Specialists. Effectiveness of media package was measured in terms of mean change in health benefit, its nutritive value and usage into different forms for curing various ailments and awareness level of the respondents after the exposure of the media package. Interview schedule was constructed to collect data into two phases. Before exposure to media package data regarding status of growing and awareness level of Aloe vera plant. Printed materials related to plant were distributed to the respondents. WhatsApp message and video clips were sent to the rural women. After 25 days post awareness data were collected. Results of the study showed significant change between pre and post awareness mean score for its all parameters. So, the prepared media package was proved to be effective to motivate people.

INTRODUCTION

Aloe vera, a succulent plant with thick, fleshy leaves, is renowned for its wide-ranging health and cosmetic benefits. Originating from the Arabian Peninsula, this versatile plant is now cultivated globally in tropical and subtropical climates. Aloe vera's leaves contain a soothing gel that has been traditionally used for its anti-inflammatory and healing properties, making it a popular

remedy for sunburns, minor burns, and skin irritations. Beyond skincare, Aloe vera juice is consumed for its potential digestive benefits, offering hydration and a range of vitamins and minerals. Its easy cultivation and multifaceted uses have cemented Aloe vera as a staple in both traditional medicine and modern wellness practices. The plant's distinctive appearance is marked by its rosette of long, lance-shaped leaves that are typically green to gray-green. These leaves are not only visually striking but also functional,

containing a clear, gel-like substance that is central to the plant's therapeutic properties. This gel, which is extracted from the inner leaf, is renowned for its soothing and healing qualities. For centuries, Aloe vera gel has been employed in various cultures to treat a range of ailments, from minor burns and sunburns to skin irritations and wounds. Its application extends beyond simple relief; the gel has anti-inflammatory, antimicrobial, and moisturizing effects, making it a valuable ingredient in many over-the-counter skincare products. Aloe vera juice, derived from the same plant, is consumed for its purported digestive advantages. It is believed to help soothe the gastrointestinal tract, aid in digestion, and provide a mild laxative effect. Aloe vera juice contains a host of vitamins, including A, C, and E, as well as several B vitamins, which contribute to its nutritional profile. Furthermore, it is rich in minerals like calcium, magnesium, and zinc, which play essential roles in various bodily functions. Despite its benefits, it is important to consume Aloe vera juice in moderation and be mindful of potential side effects, such as digestive discomfort or laxative effects, especially when consumed in large quantities. Aloe vera is often grown in pots or containers, allowing for easy management and care. Its hardy nature and minimal water requirements make it an ideal choice for those looking to cultivate a plant with practical benefits. It is also advertised for its detoxifying properties and role in supporting liver function. So, there is need to create awareness of all benefits of Aloe vera to general public. For creating awareness to large number of people, there is shortage of human resources. To meet the above challenge there is need to develop mass media. Keeping this in view, media package was developed. Media package was operationalized as package which included booklet, WhatsApp messages and video clips contained information on health benefits of Aloe vera plant, its nutritive value and how to use Aloe vera into different form i.e. in form of juice, paste, gel and pulp. Thus, the study was conducted with the objectives to assess the status of rural women for growing Aloe vera plant and to measure the effectiveness of developed media package in terms of creating awareness among rural women related to use of Aloe vera plant for health care.

METHODOLOGY

The study was conducted in the 13 villages of Ludhiana district of Punjab State. To check the effectiveness of media package, a sample of 130 rural women from 13 villages of Ludhiana district was purposively selected for the convenience of the investigator. Ten women respondents were selected from each village. The selection of the respondents was based on their access to android, smart phones or any other more advanced handset with internet availability. They should be regular users of WhatsApp, you tube or Facebook. Prepared media package on Aloe vera was validated by 30 Subject Matter Specialists of various Departments for its relevance, completeness and correctness. Interview schedule was constructed to collect data on status of growing Aloe vera plant and to measure awareness related to health benefits of Aloe vera, its nutritive value and usage of Aloe vera plant into different forms. Data were collected into two phases. Before and after the exposure to the media package. After the first phase of data collection the media package was exposed to the respondents. The printed booklet was distributed. WhatsApp messages were sent next day to the

rural women which included messages related to introduction, health benefits and usage of Aloe vera plant into different forms. Messages were transformed into text messages, messages with pictures. Video clip with pictures, sound and text was delivered through online platform. After the dissemination of information through developed media package, a gap of a minimum of 25 days was observed to assess the change in awareness level of the respondents. During the second phase, data were collected by using the same interview schedule. To check the effectiveness of media package pre and post awareness score were compared. The awareness scores were judged on a three-point rating scale like aware, somewhat aware and not aware. These responses were assigned weightage of three, two and one scores respectively. So mean score range was between 1.00 to 3.00. Data were analyzed with the help of percentage, mean score and paired t-test.

RESULTS

Status of growing the aloe vera plants by the respondents

The status of growing Aloe vera included place of growing plants at household or commercial level. These plants can easily grow in pots, gardens and farm land which is a common practice. The source of getting the plants or seeds for growing was also included.

The data regarding distribution of respondents according to their status of growing Aloe vera have been presented in Table 1. The data revealed that Aloe vera plant was planted by 76.15 per cent of the respondents. In 49.23 per cent cases it was grown in pots and in 16.15 percent cases it was planted open in a house followed by (8.46%) respondents were growing it in the land adjoining to their houses and (2.31%) at the farm respectively. As in case of Aloe vera plants were mostly procured from relatives (26.15%), neighbours (11.54%), friends (11.54%) followed by (9.23%) from private nurseries, (6.15%) from private seed shop. Only (0.77%) of the respondents was purchasing nursery from P.A.U., Ludhiana for growing of Aloe vera plant at household level.

Table 1. Distribution of respondents according to their status of growing Aloe vera

Status	Percentage
Level of growing	
Household level	76.15
Commercial level	-
Place of growing Aloe vera	
Pots	49.23
Open land in a house	16.15
Adjoining land	8.46
At Farm	2.31
Source of getting plants/seeds	
Relatives	26.15
Friends	11.54
Colleagues	2.31
Neighbours	14.62
Private seed shop	6.15
Private nurseries	9.23
Punjab Agricultural University	0.77
Private sellers	5.38

Effectiveness of developed media package in terms of creating awareness

Effectiveness of developed media package of Aloe vera plant was measured as a mean change in health benefit of Aloe vera, its nutritive value and usage into different forms of for curing various ailments and change in awareness level of the respondents after exposure of media package.

The data regarding health benefits of Aloe vera is presented in Table 2. Change in average awareness mean score was 0.76 from 1.20 to 1.96. The change in awareness was more pronounced for its use as an antioxidant (1.56) and as a stimulator for cell growth and generator of new tissues (1.31). Before the intervention the mean score for awareness was highest in case of skin problems followed by that of improved digestion and cosmetic use in case of Aloe vera. The change in awareness about health benefits was more pronounced with respect to Aloe vera for its use as an antioxidant and as a stimulator for cell growth and generator of new tissues. The findings connected to the multiple health benefits of aloe vera are relevant with the results of research studies conducted by Nandal & Bhardwaj (2012); Sahu et al., (2013); Lanka (2018); Saxena & Bhatnagar (2020)

Information concerning the awareness of respondents regarding nutritive value of Aloe vera plant have been given in Table 3. The data exhibited improvement in awareness of respondents pertaining

to nutritive value of Aloe vera from 1.00 to 1.76 displaying a shift of 0.76 in mean score after the intervention. As for as other nutrients are concerned the change for awareness was more pronounced for calcium (2.46), sodium (2.39) followed by carbohydrate (1.45), potassium (1.42) and phosphorus (1.41).

The data obtained regarding usage into different forms of Aloe vera for curing various ailments is reported in Table 4. The awareness exhibited change to the extent of 0.69 for use of its different forms against various ailments. There was conspicuous enhancement in awareness for use of Aloe vera juice for heat burn (1.16) and for Aloe vera gel to cure eczema (1.45) and cuts, wounds and shingles (1.35) after the intervention. There was higher awareness for use of different forms of Aloe vera, viz. Aloe vera juice for ulcers, Aloe vera gel for sun burn and Aloe vera pulp for burns, boils and insect bite before the intervention. Enhancement in awareness in usage of various forms was observed in case of Aloe vera juice for heart burn, Aloe vera gel for eczema, cuts, wounds and shingles. The findings related to the usage into different forms of aloe vera are consistent with the results of research studies conducted by Dehkordi (2002); Manvitha & Bidya (2014); Guo & Mei (2016); Saxena & Bhatnagar (2020).

Data regarding level of awareness of Aloe vera plant have been presented in Table 5. The awareness level was low (100%) which got converted into medium (93.08%) and high (0.77%) after

Table 2. Change in the awareness regarding the health benefits of Aloe vera

Health benefits of Aloe vera	Before the intervention (Mean score)	After the intervention (Mean score)	Mean change
Antioxidant	1.00	2.56	1.56
Anti-inflammatory	1.15	1.67	0.52
Anti-microbial	1.14	1.73	0.59
Anti-bacterial	1.00	1.65	0.65
Ani-viral	1.00	1.85	0.85
Anti-fungal	1.00	2.07	1.07
Controls diabetes	1.59	2.38	0.79
Prevents tumour	1.00	1.59	0.59
Heals gum diseases	1.00	1.44	0.44
Improves digestion	1.59	1.61	0.02
Strengths heart and nervous system	1.00	1.71	0.71
Stimulate cell growth and generate new healthy tissue	1.01	2.32	1.31
Used in cosmetic products	1.59	2.45	0.86
Skin problem	1.78	2.35	0.57
Average mean	1.20	1.96	0.76

*Mean range (1-3)

Table 3. Change in the awareness regarding the nutritive value of Aloe vera

Nutritive value of Aloe vera	Before the intervention (Mean score)	After the intervention (Mean score)	Mean change
Aloe vera			
Carbohydrate	1.00	1.45	0.45
Sodium	1.00	2.39	1.39
Calcium	1.02	2.46	1.44
Potassium	1.00	1.42	0.42
Phosphorus	1.00	1.41	0.41
Average mean	1.00	1.76	0.76

*Mean range (1-3)

Table 4. Change in the awareness regarding the usage into different forms of Aloe vera for curing various ailments (n=130)

Different forms of Aloe vera for curing various ailments	Before the intervention (Mean score)	After the intervention (Mean score)	Mean change
Aloe vera juice			
Ulcers	1.95	2.35	0.40
Heart burn	1.00	2.16	1.16
Arthritis	1.00	1.55	0.55
Ear infection	1.00	1.56	0.56
Stomach pain	1.00	1.55	0.55
Aloe vera paste			
Constipation	1.00	1.72	0.72
Aloe vera gel			
Sun burn	1.95	2.46	0.51
Eczema	1.00	2.45	1.45
Cuts, wounds and shingles	1.00	2.35	1.35
Sports injuries	1.00	1.63	0.63
Warts	1.00	1.56	0.56
Aloe vera pulp			
Jaundice	1.00	1.52	0.52
Eye problems	1.00	1.51	0.51
Cuts, wounds, burns and boils	1.98	2.24	0.26
Insect bites	1.00	1.55	0.55
Average mean	1.19	1.88	0.69

Table 5. Level of awareness regarding Aloe vera plant

Level of awareness	Before the intervention f (%)	After the intervention f (%)	Percentage change
Health benefits			
Low (14-23)	130 (100.00)	8 (6.15)	-93.85
Medium (24-33)	-	121 (93.08)	93.08
High (34-42)	-	1 (0.77)	0.77
Nutritive value			
Low (5-8)	130 (100.00)	36 (27.69)	-72.31
Medium (9-12)	-	94 (72.31)	72.31
High (13-15)	-	-	-
Usage into different forms of Aloe vera for curing various ailments			
Low (16-26)	130 (100.00)	25 (19.23)	-80.77
Medium (27-37)	-	101(77.69)	77.69
High (38-48)	-	4 (3.08)	3.08

Table 6. Distribution of respondents according to the overall awareness regarding Aloe vera plant

Parameters of Aloe vera	Before the intervention (Mean score)	After the intervention (Mean score)	Mean change	t-value
Health benefits of Aloe vera	1.20	1.96	0.76	46.47**
Nutritive value of Aloe vera	1.00	1.76	0.76	40.47**
Usage into different forms of Aloe vera for curing various ailments	1.19	1.88	0.69	28.43**

*Mean range (1-3), Significant at 1% level of significance

intervention depicting a change in favour of medium (93.08%). The awareness level regarding nutritive value of Aloe vera was low (100.00%) before the intervention and awareness level after the intervention showed change to medium level (72.31%). In Aloe vera the low level of awareness (100%) regarding the usage into different forms of medicinal plants for curing various ailments showed a change to medium (77.69%) level after intervention. The findings

of the study regarding level of awareness are consistent with the results of research studies conducted by Roy & Ghosh (2022); Gupta et al., (2024).

The data related to overall awareness regarding Aloe vera plant have been shown in Table 6. The data disclosed significant change in awareness. The mean change in awareness was equal in case of health benefits (0.76) and nutritive value (0.76) after intervention

and lowest in case of usage into different forms of Aloe vera for curing various ailments (0.69). From t value it could be inferred that the difference in the mean score obtained from pre and post exposure was significantly indicating that the respondents had gained awareness regarding all parameters of Aloe vera. Thus, it could be concluded that the use of developed media package was effective. The study findings are supported by Kaur et al., (2022); Kaur & Kaur (2023). They concluded that WhatsApp messages and video clips were effective for imparting the knowledge to rural women of Ludhiana district of Punjab.

DISCUSSION

Aloe vera was grown by respondents at household level, they were not cultivated on commercial scale. The probable reasons for this could be constraint of land, lack of marketing and they have been uneconomical because of unavailability of minimum support price and remunerative prices. Aloe vera was grown by nearly half of the respondents in pots followed by planting open in a house. The most important sources of Aloe vera plants or seeds were neighbours, relatives and friends. The respondents usually purchased very less seed or plants from Punjab Agricultural University as all of them were rural women. Probably they were not fully aware of the availability of seeds or plants from PAU. Moreover, the accessibility of seeds or plants in the neighbourhood and from relatives was more convenient.

Before the intervention the mean score for awareness regarding health benefits of Aloe vera was highest in case of skin problems followed by improved digestion and cosmetic use. The change in awareness after the intervention about health benefits of Aloe vera was more noticeable for its use as an antioxidant and as a stimulator for cell growth and generator of new tissues. The findings connected to the multiple health benefits of Aloe vera are relevant with the results of research studies conducted by Nandal & Bhardwaj (2012); Sahu et al., (2013); Lanka (2018); Saxena & Bhatnagar (2020). The change in awareness was more noticeable as the respondents were less aware about their nutritive value before the intervention.

There was higher awareness for usage of different forms of Aloe vera for curing various ailments i.e. Aloe vera juice for ulcers, Aloe vera gel for sun burn and Aloe vera pulp for burns, boils and insect bite before the intervention. Enhancement in awareness in usage of various forms was observed in case of Aloe vera juice for heart burn, Aloe vera gel for eczema, cuts, wounds and shingles. The findings related to the usage into different forms of Aloe vera are consistent with the results of research studies conducted by Dehkordi (2002); Manvitha & Bidya (2014); Guo & Mei (2016); Saxena & Bhatnagar (2020). Awareness level for health benefits of Aloe vera was low before the intervention. However, it was converted to medium level after the intervention. The findings related to awareness of health benefits of Aloe vera are consistent with the results of research studies conducted by Jyoti (2015) & Sharma (2015).

Low level of awareness for nutritive value was displayed for Aloe vera plant before the intervention. The awareness showed considerable shift to medium level after the intervention. The findings of the study are consistent with the results of research

studies conducted by Singh (2022). He studied nutritive value of natural sweeteners of Punjab. The level of awareness among respondents regarding usage into different forms of Aloe vera plant for curing various ailments was low before the intervention. On the whole low level of awareness changed after the intervention to medium level. The mean change in awareness was equal in case of health benefits and nutritive value after the intervention and was lowest in case of usage into different forms of Aloe vera for curing various ailments. The difference in mean scores obtained from pre and post exposure indicated that the respondents had gained awareness regarding all parameters of Aloe vera.

During first phase of data collection respondents had low level of awareness regarding all parameters of Aloe vera plant. But after exposure it was changed upto medium level, the reason for medium level of awareness may be that it is difficult to memorize all things. Significant change was seen between pre and post awareness data. Prepared media package is proved to be effective to motivate people for growing and creating awareness about Aloe vera plant. The findings are in line with the results of research study Geethalakshmi et al., (2024). They suggest that digital media is an effective tool for amplifying farming and rural upliftment

CONCLUSION

Not even a single respondent was growing Aloe vera at commercial level. Only negligible percentage (0.77%) of the respondents was purchasing nursery from P.A.U., Ludhiana for growing of Aloe vera plant at household level. It is suggested that there is further need of extension work for promotion and popularization of Aloe vera for economic benefits of the farmers. Significant change between pre and post awareness mean score of Aloe vera plant for all parameters i.e. its health benefits, nutritive value and its usage into different forms of selected medicinal plants for curing various ailments was observed. Awareness level of the respondents had also increased after the exposure of media package. So, prepared media package is proved to be effective to motivate people for growing and creating awareness about Aloe vera plant. This media package can be used by Extension Personnel for their wider outreach.

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Adoption of Soil Health Card by Farmers in Haryana: Perceptions, Challenges and Way Forward

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HIGHLIGHTS

- Farmers believed that adopting the soil health card tailored fertilizer doses could lead to reduction in crop yield.
- Farmers perceived the annual lease land system as a severe constraint in getting soil health card.
- Further reduction in the per-bag quantity of urea could lead to an overall increase in its consumption.
- Regular visits of mobile soil testing vans in field could increase the adoption of soil health card.

ARTICLE INFO

Keywords: Soil health, Fertilizer, Haryana, Leasehold land system, Adoption, Impediments.

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ABSTRACT

The Soil Health Card (SHC) program aims to enhance soil health by providing farmers with detailed information about the nutrient status of their soil. This study investigated farmers' perceptions, challenges, and potential pathways to enhance the adoption of SHC recommendations in Haryana. The analysis was based on primary data collected through face-to-face interviews with SHC adopters and non-adopters, utilizing a pre-tested semi-structured schedule in 2024. The findings revealed that farmers' perceptions of the benefits of the SHC remained low. The perceived constraints in obtaining SHC scored higher than those associated with implementing its recommendations. The study identified the annual lease land system as a key factor driving the indiscriminate use of fertilizers in the state. Although the recent reduction in the per-bag quantity of urea decreased usage in Haryana, any further reduction in bag weight might result in increased fertilizer consumption. The study recommended the use of mobile soil testing vans and timely delivery of soil health cards to promote greater adoption.

INTRODUCTION

Haryana has been an early adopter of chemical fertilizer based green revolution technology. Presently, the state has become second leading user of chemical fertilizers. However, the actual usage of fertilizers in the state deviates significantly from the recommended levels, with farmers reportedly applying excessive doses of nitrogenous fertilizers (Chand & Pavithra, 2015; Bora, 2022). While this practice may offer short-term benefits, the indiscriminate and high use of chemical fertilizers has raised significant challenges for the long-term sustainability of agriculture

in Haryana (Veluguri et al., 2019). Overexploitation of soil and unbalanced fertilizer use have led to nutrient deficiencies and declining soil fertility, particularly in areas of intensive farming (Rani, 2019; Ohlan, 2021a).

India's National Mission on Sustainable Agriculture (NMSA), a component of the National Action Plan on Climate Change (NAPCC), emphasizes improving soil health, which aligns with the United Nations' Sustainable Development Goal 15 (SDG#15): Life on Land (Keesstra et al., 2018). SDG 15 recognizes agriculture as a critical economic resource and advocates for protecting land from degradation. In line with this goal, the Government of India (GoI)

launched the Soil Health Card Scheme (SHCS) in 2015 to promote agricultural sustainability through better soil nutrient management. This scheme enables farmers to have their soil tested by certified agencies, which then provide a Soil Health Card (SHC). The SHC offers detailed information on the nutrient status of their soil and provides crop-specific fertilizer recommendations to ensure rationale use of inputs. It aims to promote sustainable agricultural practices by facilitating balanced use of fertilizers (Purakayastha et al., 2019).

The theoretical justification behind the SHCS draws from regenerative economics, which emphasizes sustainable practices (Dominati et al., 2019). However, the adoption of SHC recommendations depends heavily on farmers' perceptions and the challenges they face. These challenges vary by region, making it crucial to examine the specific factors affecting adoption in Haryana. Additionally, the GoI has recently changed the packaging of urea (nitrogenous fertilizer) by reducing its per-bag quantity from 50 kilogram (kg) to 45 kg. The objective of this ad hoc quantitative policy measure is to promote balanced use of fertilizer. It is, therefore, instructive to know the implication of this change in packaging of urea for fertilizer consumption in the state. A review of existing literature reveals a knowledge gap: while farmers are aware of this soil health testing scheme, little attention has been paid to analyze the constraints faced by farmers in Haryana, particularly regarding non-users of the SHC and tenant farmers. Additionally, the likely impact of recent measure for balanced use of fertilizer through reduction in per-bag quantity of urea is yet to be assessed in the state. This study seeks to address these gaps by exploring farmers' perceptions toward the SHC in Haryana and identifying the barriers to adopting its recommendations. The novel findings contribute to scientific knowledge to enhance the uptake of SHC practices. Additionally, the study offers valuable feedback to stakeholders, aiding in the more effective implementation of this policy.

METHODOLOGY

This study used a mixed-methods approach, combining quantitative surveys with qualitative interviews. The data for this study were collected through a farm-level field survey conducted in the Yamunanagar, Karnal, Kurukshetra, Rewari, Mahendragarh and Sirsa districts of Haryana in 2024-25. These districts were chosen based on their specialization in different crops grown in the state. This comprehensive study covers six main crops grown in Haryana, namely wheat, paddy, mustard, sugarcane, bajra, and cotton. These crops accounted for 85.12 per cent of gross area sown in the state in 2022-23. Given the large size of the population, applying Cochran (Potapov et al., 2022) sampling formula, at a 95 per cent level of confidence and a 5 per cent level of margin, the representative sample size was 396 respondents. Preliminary information on adopter of SHC was obtained from nearby soil health testing labs. A purposive sampling approach was adopted for choosing the sites for the survey. One block having high presence of adopters of SHC was marked from each district. By using the same method, three villages were selected from every block. A list of all farmers adopting SHC was prepared for every selected village. From each village, 11 SHC adopters were selected

randomly. To isolate the impact of difference in soil fertility on use of fertilizer, the 11 farmers in each control group were selected from the nearby farms of farmers of experimental group by preparing a separate list and then choosing randomly.

Farmers were individually interviewed using a face to face method applying a pre-tested and semi-structured schedule. Participation in the survey was voluntary based on consent of farmers. Farmers' perception on utility, challenges and way forward in adopting SHC was sought using the five points Likert's scale with responses ranged from one (strongly disagree) to five (strongly agree). Additionally, the opinion of fertilizer retailers on changes in farmers' fertilizer purchasing patterns, due to the reduction in per-bag urea quantity, was gathered through qualitative personal interviews. In doing so, one fertilizer retailer was randomly selected from each district included in the study. The statistical techniques including, mean score (arithmetic mean), percentage (hundred times of mean score divided by highest potential value of scale), standard deviation, and standard error (standard deviation divided by square root of sample size) were applied to analyze the primary data.

RESULTS

Farmers' perceptions towards soil health card

Table 1 presents empirical estimates of farmers' perception regarding utility of SHC, analyzed using arithmetic mean, percentage, standard deviation, and standard error. For most items, the standard deviation was less than one, indicating consistency in farmers' responses. Additionally, the low standard error values, ranging from 0.03 to 0.07, suggested that the sample was representative of the broader population.

The results reported in Table 1 reveal that the mean scores of various items varied across several aspects of SHC. The highest perception was regarding the potential adverse impact of adopting recommended doses of fertilizers on crop yield (MS: 3.61), with a high percentage of 72.22. This was followed by farmers' perceptions of the sample collection method and the reliability of SHC information, with mean scores of 3.58 and 3.52, respectively. Other items with mean scores above three included the usefulness of SHC in the judicious use of fertilizers (MS: 3.40), improving soil sustainability (MS: 3.38), reducing the cost of fertilization (MS: 3.37), the validity of information reported in SHC (MS: 3.35), and managing micronutrients (MS: 3.14).

On contrary, farmers' perception was lowest (MS: 2.09) regarding its usefulness in restoring fertility of problematic soil. Notably, farmers had a low perception even about purpose of SHC (MS: 2.98). Similarly, their perceptions of the ease of adopting recommendations provided in SHC (MS: 2.45) and its usefulness in addressing problem of macronutrient deficiency in soil (MS: 2.95) were relatively low.

Implication of reduction in per-bag quantity of urea on fertilizer consumption

A four-point scale was used for assessing the likely impact of reducing per-bag urea quantity on fertilizer consumption, with responses as follows: one (no purchase of extra urea), two (purchase of extra urea, but less than the amount needed to

Table 1. Farmers' perceptions about soil health card

S.No.	Perception	MS	Percentage	SD	SE
1	SHC intends to help farmers	2.98	59.60	1.03	0.05
2	Soil samples collecting methods are scientific	3.58	71.62	1.20	0.06
3	SHC information is reliable	3.52	70.30	0.91	0.05
4	Recommendation given in SHC is simple to adopt	2.45	49.04	0.89	0.04
5	Macronutrient management is possible with SHC	2.95	59.04	1.25	0.06
6	Micronutrient management is possible with SHC	3.14	62.78	1.17	0.06
7	SHC is useful to reduce cost of fertilization	3.37	67.47	1.33	0.07
8	SHC helps to improve soil sustainability	3.38	67.63	0.88	0.04
9	SHC is useful in restoring fertility of problematic soil	2.09	41.87	0.70	0.04
10	Validity of SHC is temporary	3.35	66.97	0.91	0.05
11	SHC helps to check the indiscriminate use of fertilizers	3.40	67.98	0.65	0.03
12	SCH tailored doses of fertilizers reduces the crop yield	3.61	72.22	0.85	0.04

MS = Mean Score, SD = Standard Deviation, SE = Standard Error.

The perceptions reported in Table 1 are adapted from Ravikishore et al., (2021); Singh et al., (2023).

compensate for the original quantity), three (purchase of extra urea to maintain the original quantity), and four (purchase of extra urea exceeding the amount required to restore the original quantity). Table 2 gives estimates of farmers' preferences on additional use of fertilizer resulting from a reduction in urea bag weight. The average response (MS: 1.79) value was found to be lowest regarding farmers' choice of purchase of an extra quantity of urea in response of existing reduction in its per-bag quantity from 50 kg to 45 kg. Similarly, their likelihood of purchasing an extra dose of other fertilizers was also found to be low (MS: 1.84). On the other hand, the mean value (MS: 3.46) was highest in the context of their potential choice in response of any further reduction in per bag urea quantity by GoI. A total of 86.43 per cent of farmers expressed approval for purchasing additional urea if the government further reduces the per-bag quantity. The value of standard deviation (SD: 0.90) was lowest and less than unity for this item.

Pattern of adoption of soil health card

Farmers' response to the statements concerning pattern of adoption of SHC is quantified in Table 3. The mean scores for all three items assessing the adoption pattern of SHC recommendations

indicate a relatively low level of adoption. For instance, the mean score for adopting SHC-tailored recommendations is 1.58, which corresponds to 31.52 per cent of the scale. Moreover, the majority of farmers have not obtained SHC for all their plots of land. Similarly, they do not regularly acquire SHC for the same piece of land.

Constraints in adoption of soil health card

Table 4 provides empirical estimates for major constraints in acquiring soil health card and adopting its recommendations. The mean response score ranged between 4.26, for leasehold land system, and 1.89 for potential increase in cost of fertilization. A total of 80.20 per cent farmers agreed with the statement that the ongoing tenant and land owner relationship does not provide assurance for getting same land for next year. On an average, the mean score of perceived constraints in getting SHC was higher than those of implementing its recommendations. The value of standard deviation for all items was found below unity. The value of SE was also low, indicating the validity of results. More specifically, farmers refuted concerns about the high cost of obtaining a SHC (MS: 2.26), limited access to soil health testing laboratories (MS: 2.26), increased

Table 2. Preferences regarding use of fertilizer

S.No.	Statement	MS	Percentage	SD	SE
1	You purchase an extra quantity of urea after reduction in per-bag urea quantity from 50 kg to 45 kg	1.79	44.82	1.00	0.05
2	You use an extra dose of other fertilizers after reduction in weight of urea bag	1.84	46.02	0.93	0.05
3	You would like to purchase an extra quantity of urea if government further reduces 45 kg to 40 kg per-bag urea quantity	3.46	86.43	0.90	0.05

Note: MS = Mean Score, SD = Standard Deviation, SE = Standard Error.

Table 3. Pattern of adoption of soil health card

S.No.	Item	MS	Percentage	SD	SE
1	You have gotten SCH for all pieces of land	2.22	44.34	1.21	0.09
2	You regularly obtain SHC after every 3 years	2.17	43.33	1.12	0.08
3	You have fully adopted SCH tailored recommendations	1.58	31.52	0.80	0.06

Note: MS = Mean Score, SD = Standard Deviation, SE = Standard Error.

The statements presented in Table 3 are adapted from Madhuri et al. (2024).

Table 4. Constraints in adoption of soil health card

S.No.	Constraint	MS	Percentage	SD	SE
a	Perceived constraint in getting SHC				
1	Leasehold land system	4.26	85.10	0.67	0.03
2	Lack of assurance for getting same land for next year	4.01	80.20	0.87	0.04
3	High cost of getting SHC	2.26	45.25	0.65	0.03
4	Soil health testing laboratory is far away from village	2.57	43.03	0.57	0.03
5	Soil health report does not received timely	3.63	72.53	0.48	0.02
b	Perceived constraint in adopting SHC recommendation				
6	Adverse impact on crop yield	3.74	74.75	0.66	0.03
7	Increase in cost of fertilization	1.89	43.79	0.51	0.02
8	Adequate quantity of required fertilizer was not available	3.68	73.69	0.80	0.04
9	Lack of understanding of tailored recommendations	2.07	41.41	0.66	0.03
10	Inadequate follow-up by extension agency	3.69	73.84	0.46	0.02

Note: MS = Mean Score, SD = Standard Deviation, SE = Standard Error.

The constraint items given in Table 4 are adapted from Ravikishore et al., (2021); Singh et al., (2023).

Table 5. Pathways for improving the adoption of soil health card

S.No.	Measure	MS	Percentage	SD	SE
1	Distribution of hard copies of SHC to farmers without any initiative on their part	3.48	69.60	1.07	0.05
2	Regular visits of mobile soil testing van	3.13	62.53	1.15	0.06
3	Quick distribution of soil health cards	3.27	65.40	1.20	0.06
4	Organizing regular awareness camps by extension agency	3.42	68.33	0.93	0.05
5	Regularly conducting demonstrations	3.04	60.86	1.12	0.06
6	Follow up on use of SHC tailored recommendations	3.26	65.10	1.12	0.06

Note: MS = Mean Score, SD = Standard Deviation, SE = Standard Error.

fertilization costs (MS: 2.26), and a lack of understanding of tailored recommendations (MS: 2.07).

The way forward

Table 5 presents quantitative values of statements regarding farmers' perception about potential way forward for improving the adoption of soil health card. The mean value of all items representing suggestions for improving the adoption of SHC was above three. The data reported in Table 5 revealed that 69.6 per cent of the surveyed farmers seen distribution of hard copies of SHC to all farmers without any initiative on their part as a potential remedy for increasing its adoption. Likewise, 68.33 per cent farmers approved the statement regarding organizing regular awareness camps by extension agencies.

DISCUSSION

The majority of farmers are uncertain whether the SHC is truly intended to promote the balanced use of fertilizers. Many of them view the SHC merely as a tool for assessing soil quality for benefit of health of consumers of farm produce, rather than as a comprehensive guide to improve soil fertility and optimize fertilizer use (Ohlan, 2021b). They do not perceive that SHC is indented to farmers' welfare. A common quote from the majority of farmers in response to a question regarding the purpose of this scheme is stated below:

My land is fertile, and its produce is good for human consumption

Farmers express that the recommendations provided in the SHC are not always easy to implement. For instance, the

recommended quantity of Diammonium Phosphate (DAP) fertilizer required for sowing rabbi crops (e.g., wheat and mustard) is sometimes unavailable in the market, leading to an overuse of urea. Similarly, farmers are uncertain whether the fertility of problematic soils can be restored by following the SHC recommendations. In such cases, they often prefer traditional practices such as green manuring, organic manuring, crop rotation, or even taking a crop holiday (Purakayastha et al., 2019). Several farmers agreed that adoption of recommendations given in SHC led to a reduction in cost of fertilization. However, a few farmers have expressed concerns regarding an additional cost of purchasing micronutrients.

In contrast, the majority of farmers believe that adopting the recommended doses of fertilizers can potentially reduce their crop yield. This finding highlights the fact that farmers viewed the additional use of urea as a means to increase crop yield. Farmers in Australia shared a similar perception (Bennett et al., 2014). This perception has made them hesitant to adopt the SHC, as they are concerned about risking lower productivity. Farmers have perceived the SHC primarily as a tool for micronutrient management rather than for macronutrient management. They also recognize that the nutrient status of the soil is dynamic and therefore understood that the results reported in the SHC are only valid for a limited period.

Regarding the reduction in per-bag quantity of urea, farmers do not agree with the notion that they have purchased additional quantities of urea or any other fertilizer to compensate for this reduction. This may be due to the high prevalence of small and resource-poor marginal farmers in the state (Ohlan, 2021c). Additionally, there is a lack of efficient substitutes for urea in the market (Reddy et al., 2024). According to farmers and supported by fertilizer retailers, for most major crops grown in Haryana (e.g., wheat, rice, sugarcane, cotton), farmers typically apply urea by

the number of bags rather than by weight in kilograms. Farmers largely determined urea application based on crop health (Aryal et al., 2021). Consequently, farmers strongly argued that any further reduction in the per-bag quantity of urea would require them to use an additional bag per acre, which would ultimately increase overall consumption.

The finding did not support the hypothesis that farmers fully and sustainably adopted recommendations of the soil health card. The primary obstacle farmers faced in obtaining SHC is the annual leasehold land system. This system discourages tenant farmers from prioritizing soil health, as farming leases were largely informal and provided no assurance of accessing the same land the following year. Consequently, tenant farmers are less motivated to invest in long-term aspects of soil health. Farmers need to prioritize sustainable soil management over immediate returns from leased lands. While farmers perceived a potential increase in fertilization costs as a minor issue, they reported significant delays in receiving SHCs after submitting soil samples. This finding regarding delay in issuing SHC aligns with that reported in Kaur et al., (2020) and Madhuri et al., (2024) concerning farmers in Punjab and Andhra Pradesh, respectively. However, the costs associated with obtaining a SHC and the distance to soil health laboratories are not considered major barriers to soil testing. This may be attributed to the recent increase in the number of soil health testing laboratories in the state.

The major constraint confronted by farmers in adopting SHC-tailored recommendations is the potential adverse impact on crop yield. As noted above, farmers perceived the unavailability of required fertilizers as a major issue contributing to unbalanced fertilization. Adopting SHC recommendations is not seen as increasing fertilization costs, nor was understanding these recommendations reported as a significant challenge, possibly due to the rising education levels in the state. However, inadequate follow-up by extension agencies was identified as a barrier to the sustainable adoption of SHC recommendations. This finding aligns with the observations of Patel et al., (2023) concerning cereal cultivators in Bihar.

To improve SHC adoption, the majority of farmers expressed that the government should take full responsibility for conducting soil testing, suggesting this be implemented through regular visits by mobile soil testing vans. This finding supports the results reported in Singh et al., (2023). Apart from this, farmers expected timely distribution of soil health cards. Likewise, farmers supported the usefulness of organizing more awareness programs on the importance of micronutrients and balanced use of fertilizers in maintaining soil fertility and health. They emphasized that non-government organizations and government organizations like farm science centers should conduct demonstrations on successful adoption of SCH. These trainings should be followed up by extension experts to monitor the progress of the adoption of recommended use of fertilizers. Future research could focus on assessing the implications of the SHCS for horticultural crops in the state, including fruits, vegetables, flowers, spices, ornamental plants, and medicinal herbs.

CONCLUSION

It was found that the majority of farmers in Haryana have a limited perception of the potential benefits of adopting SHC. The

annual lease land system was perceived as a considerable constraint in adopting soil health card in the state. Farmers expressed concerns that the adoption of SHC recommendations may reduce crop yields. Additionally, the study established that the existing reduction in the per-bag quantity of urea by the GoI has succeeded in promoting judicious fertilizer use. However, any further reduction may risk imbalanced fertilizer practices, as farmers may offset the lower quantity per bag by increasing the number of bags applied per acre. These findings carry important implications for extension services aiming to improve SHC adoption rates.

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Global Research Trends in Family Farming: A Bibliometric Insight

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HIGHLIGHTS

- Family farming accounts for 80 per cent of global food production and supports the SDGs, making it essential for biodiversity conservation, climate resilience, and global food security.
- Contribution to family farming research from Brazil and European countries showing global interest in this dynamic research field.
- Research focus has shifted from traditional agricultural practices to interdisciplinary themes like agroecology, gender roles and rural development
- The incorporation of digital technology, youth participation, and the deepening of agricultural ties between urban and rural areas.

ARTICLE INFO

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ABSTRACT

Family farming is considered as most sustainable form of agriculture, which is accepted worldwide. It is integral to food production, rural livelihood and cultural heritage. The concept of family farming changed significantly over time. The study utilizes the bibliometric analysis approach to examine the dynamic concept of family farming in the agricultural sector over the decade. The data is extracted from the Scopus database from 2015-2024 and analysed using bibliometric tools such as R Studio and VOSviewer. The study presents a thorough and measurable evaluation of the contributions from different countries, keyword frequencies and research trends with thematic evolution, offering a more empirical knowledge of the subject. The study investigates that the research has increasingly emphasized integrated and sustainable practices such as agroecology, gender role in farming and rural development policies. This shift reflects a growing recognition of family farming's role in promoting sustainable agriculture, addressing global challenges and shaping a food-secure future for generations to come. To advance this crucial area of research, researchers, policymakers, and family farmers themselves must continue to work together.

INTRODUCTION

The concept of “family farming” is frequently used in popular and scientific articles, but there is no single and accepted definition that explains the concept of family farming. There are more than 600 million family farms worldwide which utilize only 30 per cent of the workforce but produce over 80 per cent of the world's food in terms of value (Food and Agriculture Organization, 2014). It plays a significant role as stewards of ecosystems, panoramas and

cultural treasures making them essential to the development of more inclusive, environmentally friendly, adaptable and efficient agri-food systems. The family farm can be linked to entrepreneurial skills, options, hazards, and personal achievement from a financial point of view. From a social point of view, the family farm is linked to family virtue, the practice of solidarity, continuity, and commitment (Szydlak, 2008). The connection between these two perspectives suggests that family farming represents a way of life that is founded on customs and beliefs about working and living, in addition to being

an economic endeavour (Nain et al., 2014). The family can be seen as a kind of filter between the farm and the non-farm world, separating ideas, resources, and energy (Fuller et al., 2021).

Family farming is a traditional form of agriculture, characterized by family workforce and intergenerational transfer of knowledge which maintain agricultural biodiversity, cultural heritage and rural livelihoods (Suess-Reyes & Fuetsch, 2016). In the last few decades, family farming has made a shift to address contemporary issues such as food security, climate change and livelihood development. It increasingly focuses on sustainability, aiming to reduce environmental impact, improve soil health and enhance climate resilience by exploring agroecological methods, organic farming and integrating traditional knowledge with modern techniques (Chao, 2024; Kumari et al., 2024). More research has been done on socio-economic aspect of family farming, which involves factors like agricultural inputs, credit and market accessibility. Studies emphasized the role of family farming in reducing rural poverty and promoting social inclusion (Chandran et al., 2023). Researchers aim to formulate policies that support the sustainability and growth of these family farms. Technological advancements such as precision agriculture, digital tools and innovative farming techniques have been studied to understand their impact on family farms. These technologies have the potential to reduce labour demands, enhance productivity and improve resource management whereas, issues like cost, accessibility, and capacity building among farmers are also considered. Research also emphasizes the significance of gender roles and youth engagement, as empowering women and youth in the sector can lead to improved agricultural outcomes and community development (Saha et al., 2024). This bibliometric study explores trends in family farming research, focusing on publications, geographical contribution and key themes in academic and scientific community. It seeks to analyse the diverse and complex nature of family farming and shifts in the thematic areas of research over the decade and ultimately, contribute in the development of a sustainable and resilient agricultural system.

METHODOLOGY

Bibliometric analysis is a systematic and quantitative approach to research trends and evolution in a specific field. It analyses and visualizes the structure and dynamics of scholarly communication, giving insights into the development and trajectory of a field (Javed et al., 2024). The study adopted a bibliometric analysis approach to evaluate the research trends in the agricultural sector concerning family farming within the last decade. The data for this analysis was sourced from the Scopus database, using the search string: KEY (family AND farming) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (EXACTKEYWORD, "FamilyFarming") OR LIMIT-TO (EXACTKEYWORD, "FamilyFarm")) AND (LIMIT-TO (SUBJAREA, "AGRI") OR LIMIT-TO (SUBJAREA, "SOC")) AND (LIMIT-TO (DOCTYPE, "ar")). The study utilizes Scopus data due to its wide coverage and high-quality indexing. The search aimed to research articles published between 2015 and 2024 that focused on family farming and related topics, with the subject areas restricted to agriculture (AGRI) and social sciences (SOCI). The articles classified under the keywords "family farming" and "family farm" were only included in the study, ensuring a focused

exploration of research trends specifically within these domains. The type of document for the study was limited to research articles ("ar") to ensure consistency and high data quality.

A bibliometric search was conducted in October 2024. It resulted in retrieving 605 documents from 248 different sources for ten years. All the relevant metadata such as title, names of authors, and journal names with year of publication and keywords and citations were downloaded for analysis. This period was chosen to provide a comprehensive understanding of recent developments and trends in family farming research and the changing trends in this field.

The collected data was processed and analysed using the R Studio and VOSviewer, which are robust tools for bibliometric analysis (Roy et al., 2024). Data on publication volume was taken from Scopus results, citations by country, three field plot, trend analysis, tree map and thematic mapping are analysed by R Studio while Co-occurrence Network is analysed by VOSviewer. This methodology provides a systematic and quantitative assessment of family farming research trends, providing valuable insights into the academic discourse related to this crucial topic.

RESULTS

Growth of research in family farming

Family farming has been an upsurge growth area of research, which gained significant momentum, especially since the mid-2000s. These grew in close association with international efforts towards global food security, climate resilience, and SDGs. The United Nations declared 2014 as the "International Year of Family Farming," and research experienced a surge in both policy and academic focus for the subject. Because family farms often have a spot in sustainable agricultural development, much of today's writing points out their role in biodiversity conservation, adaptation to change because of climate, and stability in terms of rural economic forms. The volumes of publications on family farming from 2015 to 2024 show the influence of the International Year of Family Farming in 2014. First, it increased to 50 in 2015 and then decreased marginally in 2016, but it surged with a rapid increase to 65 in 2017 with the global debate on sustainable agriculture and food security. The COVID-19 pandemic led to a great peak with 80 publications in 2020 and stabilizing around 60-65 publications from 2017 to 2019 emphasizing family farms within localized food systems. Again, publications declined from 2021 onwards, fluctuating around 60-65, indicating normalization in research interest. The trend suggests that while family farming remains important, it may be competing with emerging research areas or experiencing shifts in focus due to changing global priorities or economic pressures.

Family farming is practiced worldwide, but research-oriented activities have been concentrated in some regions only. The graph illustrates the contribution of different countries to family farming research, measured by the number of documents published. There are tremendous discrepancies in the volume of output across a vast number of countries. Brazil stands out as the top contributor, with approximately 400 documents, well above any other countries in this family farming research France ranks second in terms of the

number of publications, with around 80 publications. Spain and the United States are close behind with the moderation at about 50-60 documents. Argentina and the United Kingdom have similar levels of contributions, each with approximately 40-50 documents. Countries like Colombia, Germany, Italy, and the Netherlands have smaller but significant contributions of about 30-40 document each.

The contributions of various countries to family farming research, based on the number of citations their publications have received was analysed. Brazil leads significantly with 901 citations, reflecting its dominant role and influence in family farming studies, likely due to its vast rural landscape and importance of family farming in its agricultural sector. Austria follows with 408 citations, highlighting its focus on sustainable and small-scale farming. Ireland ranks third with 204 citations, reflecting a long tradition of family agriculture. Other European countries are Spain (180), Switzerland (163), Italy (138), and Germany (105), which shows significant academic interest in family farming within Europe. China with 136 citation and the United Kingdom with 128 citations, showing that the topic transcends the European context, while Argentina having 114 citations, which underlines the importance of family farming research in Latin America besides Brazil. This distribution highlights geographically dispersed interest with Brazil and the European countries being the leaders of citation impact in this particular field.

Thematic evolution of research

Research themes undergo significant transformations over the years providing insights into how the research landscape shifts and develops. In bibliometric studies this thematic evolution can be visualized through three-field plot diagram (Figure 1) showing the interconnectedness between authors (left column, AU), countries (middle column, AU_CO) and keywords (right column, DE). The diagram shows that most of the authors on the left side such as “nunes em”, “de freitas af”, “gazolla m”, “rover oj”, “bergamasco smpp” and “jr” are connected with Brazil in central column. After Brazil most of the authors are linked with France. Other countries such as Colombia, Argentina, Spain, Ireland, Italy, USA, Mexico and Chile are having very fewer connections to authors. Brazil in the central column is connected

with the keywords in the right column majorly with “Family Farming” and also with “Rural development”, “Family Farm” and “Agroecology”. France, Columbia and Argentina also show some connections with keywords “Family Farming”, “Rural development”, “Sustainability” and “Food security”.

“Family farming” is the most prominent keyword which is strongly linked with Brazil and also linked with France, Columbia, Argentina and very few connections with rest of the other countries. “Rural development”, “Family Farm”, “Agroecology”, “Sustainability” and “Food security” are other prominent keywords linked mainly with Brazil and very few link with other countries. Additional keywords such as “Public policy”, “Agricultura familiar” and “Public policies” are not so prominent but have fewer links with countries like Brazil and France.

The trend of keyword usage in family farming research from 2015 to 2024 is depicted in the graph (Figure 2), which also demonstrates how different themes have developed and become more popular in the sector. Every row is a distinct term, and the circle’s size indicates how frequently that term was used in a particular year. Early studies (2015-2017) focused heavily on traditional themes such as livestock farming, agricultural practice, and rural society. “Gender role” began appearing in 2017, reflecting growing attention to gender dynamics in farming. From 2017 onwards, research expanded to include food production and family farms, indicating an increased focus on agriculture, agricultural worker and rural development. The word, ‘family farms’, has the highest frequency during this time. Geographically, Brazil and Amazonia emerged as a key focus during this time. The years 2019-2021 marked a peak in research output, especially around topics like farming systems, rural economy, agroecology, gender relations and smallholder. Recent trends (2021-2023) show a continued focus on rural economy and crop production. “Farmers’ attitude” and “cluster analysis” continued to be used in 2022 and 2023.

The tree map (Figure 3) depicts the distribution of research topics by the frequency of occurrence of keywords. More extensively studied topics are represented by larger areas. “Family Farm” (29%) and “Brazil” (12%) are the two most investigated

Figure 1. Three-field plot analysis of author, countries and keywords

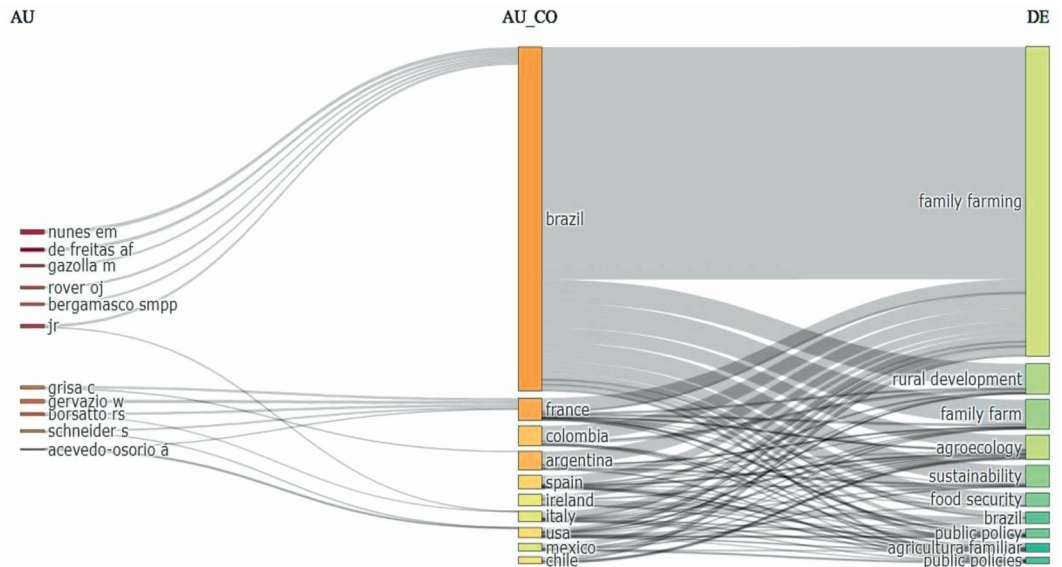


Figure 2. Trend analysis of keywords

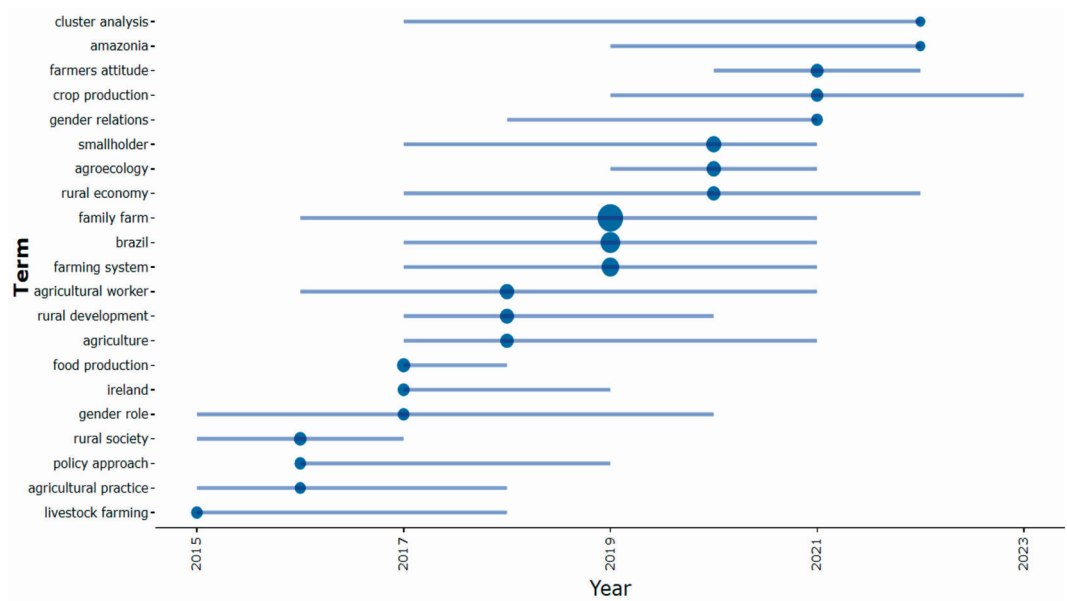


Figure 3. Tree map of keywords



themes, showing that they are the most studied subjects. Other heavily studied subjects include “farming system” (8%), “smallholder” (4%), “sustainability” (4%), and “agricultural production.” Smaller categories such as “agricultural policy” (3%), “food security,” and “rural economy” (3%) are examples of niche research keywords. In contrast, more specialized topics that are less common in the dataset include “food production,” “agricultural development,” “governance approach,” and “decision making,” which account for 2% of the total.

Thematic mapping of keywords (Figure 4) is a strategic diagram used in bibliometric analysis that plots themes or subjects according to two dimensions: centrality (X-axis) and density (Y-axis). This method is commonly used to examine the structure of the study area. The diagram shows that the research on family farms mainly focused on “smallholder farming” and “sustainability” as these are closely related to family farming.

The map is divided into four quadrants: *Motor themes* (Top-right quadrant): these themes are well-developed and highly relevant

in the research field. The placement of terms such as “Brazil,” “agroecology,” “rural development,” and “agricultural policy” here suggests that they are not just thoroughly researched but also essential to the area of study. These topics are probably essential to research on agricultural development and policy, especially in the Brazilian study. *Basic theme* (bottom-right quadrant): these themes have high relevancy but lower development. Terms like “family farm”, “farming system”, “smallholder” and “sustainability” fall under this category indicating that they are crucial but need to be more developed. These topics are fundamental and frequently serve as the basis for research on family farming and agricultural sustainability.

Niche theme (Top-left quadrant): these themes are having high density and low centrality, showing that they are well-developed but not crucial for larger study area. The terms “females”, “male”, “adult” and “farms” are distinct but not significant for the primary research goals. *Emerging or declining themes* (bottom-left quadrant): themes in this quadrant have both low

Figure 4. Thematic mapping of keywords

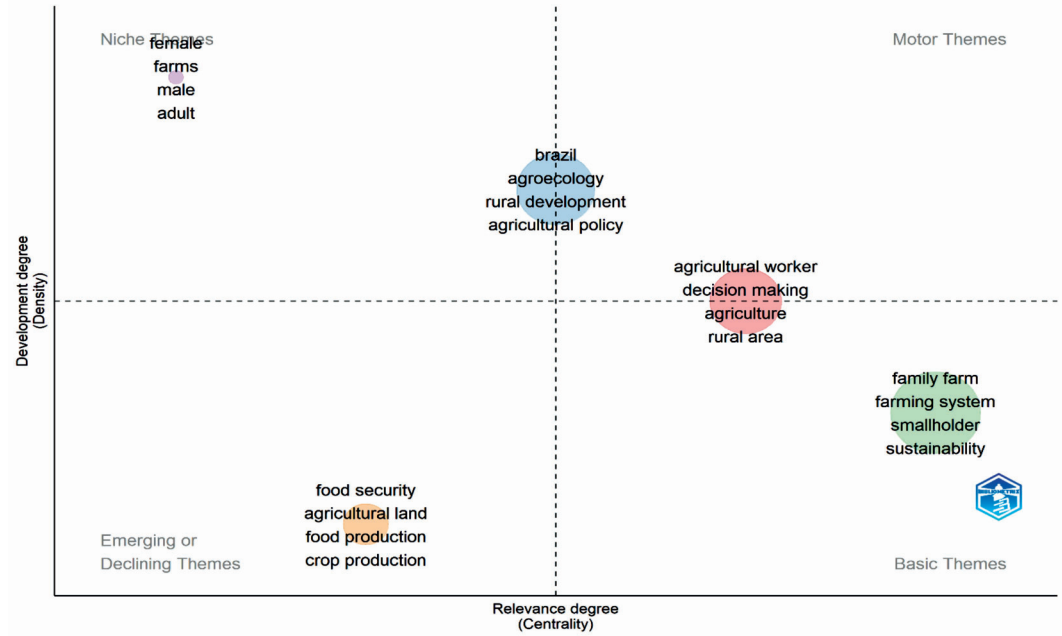
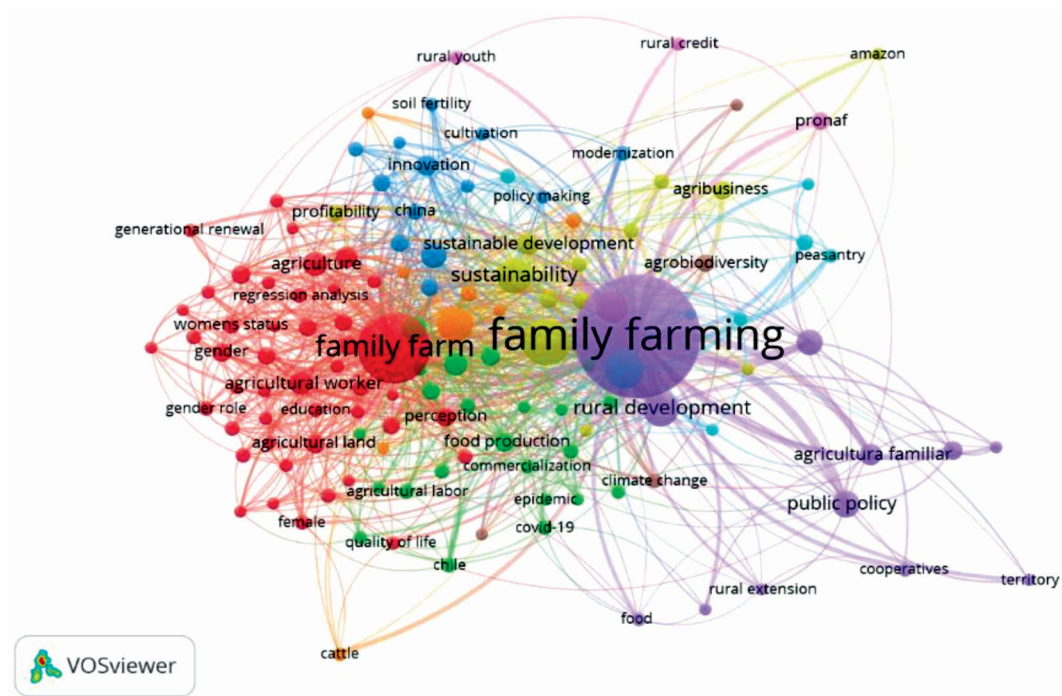


Figure 5. Co-occurrence network of keywords



density and centrality, indicating that either these themes are emerging or declining. The presence of keywords like “food security”, “agricultural land”, “food production” and “crop production” may suggest that the focus is moving from these conventional subjects to more comprehensive integrated topics like family farming system and sustainability.

Figure 5 represents the co-occurrence network map which depicts the association of keywords related to family farming. In this diagram, keywords are represented as nodes, larger nodes denote a higher frequency of the specific term and the thickness of connecting links shows the strength of co-occurrence network. The network is grouped into seven clusters denoted by seven colours,

indicating clusters of closely related terms among which only four clusters are important because the cluster contain larger nodes.

Core research area

The co-occurrence network shows some keywords with larger nodes which indicates the focus of research in these areas such as “family farming”, “family farms”, “Brazil” and “farming system”. Strong thematic cluster is present around these core research areas which is interconnected with other subtopics. *Central cluster (purple):* In this cluster, keywords such as “family farming”, “rural development” and “public policy” are dominant. The term “family farming” has largest node in the diagram showing its high-frequency

in the study area. *Red cluster*: Keywords such as “family farm”, “agriculture”, “women status” and “gender” are central showing focus of the research on social aspect. *Yellow cluster*: keywords like “Brazil”, “sustainability” and “sustainable development” are dominant and show the co-occurrence. Finally, *Orange cluster*: This cluster has dominant keywords such as “farming system” and “smallholder” and has a smaller number of terms.

DISCUSSION

The present study reveals dynamic trends in family farming research over the decade, which has been mainly driven by the global initiative of the United Nations’ 2014 declaration of the “International Year of Family Farming”. The shift in research due to this trend, highlights family farming’s role in food security, biodiversity conservation and climate resilience (Alam & Shrestha, 2021). After 2014 publication volume surged and then stabilized showing that family farming is important but it is now competing with emerging research areas like digital and climate- smart agriculture (FAO, 2024).

Geographically, Latin America and Europe account for the majority of the research activities, with France and Brazil as top contributors. Although agriculture acts as a primary industry for poverty reduction and employment in majority of Asian countries, family farming is not noticeable due to lack of land reforms, smaller farm size, mechanization of farms, diverse farming practices, resource scarcity and lack of younger generation involved in farming etc. (Ye & Pan, 2016). Brazil has a prominent role in terms of citation and publication volume which emphasize that family farming is deeply embedded in the country’s agricultural system. Significant contributions can be seen by European countries, particularly Austria, where studies focus on small-scale sustainable farming. High citation impacts from countries like China and Argentina suggest that their research is very relevant outside of Europe and Latin America. These trends highlight the continued academic interest in family farming even though the focus shifted due to global economic research priorities. High-frequency terms like “Family farming”, “Rural Development,” and “Agroecology” highlight the socioeconomic and environmental features of family farms in Brazil and worldwide (Valverde et al., 2022). The prevalence of keywords like “Sustainability” and “Food Security” across the nations demonstrates the increased interest in family farms as agents of food security and climate resilience on a global scale. Early research emphasized on conventional agricultural areas while subsequent studies included social issues such as “Gender Roles” and economic factors related to “Rural Development”. This development shows that policy talks on rural livelihoods and the function of family farming in regional food systems have sparked an increasing interest in the socioeconomic patterns seen on family farms (Graeub et al., 2016). Dominant topics like “Family Farm” and “Brazil” take up a lot of space on the tree map, indicating their importance in the conversation around family farming. This focus on Brazil is in line with the country’s sizable family farm industry, which is essential to both rural employment and food supply. The study reflects a research field that is moving toward integrated and sustainable agricultural methods, with a strong focus on “Agroecology” and policies in the Brazilian context. Fundamental

topics like family farms and sustainability remain central yet underdeveloped, representing areas for further growth in research, while traditional agricultural themes appear to be giving way to more holistic approaches in the study of family farming. In the study of family farming, traditional agricultural themes seem to be giving way to more holistic approaches, while fundamental subjects like sustainability and family farms remain important but underdeveloped, indicating possibilities for continued research expansion (Holloway et al., 2021). The Co-occurrence Network consolidates these results, which reveals robust thematic clusters around keywords like “Family Farming” and “Public Policy” reflecting their crucial linkage in the field. Overall, this analysis suggests that family farming is an interdisciplinary research area, with central hubs of study expanding from rural livelihoods and food security towards integrated socio-economic and environmental frameworks (Kumar et al., 2015).

Family farming promotes a balanced ecosystem using agroecological techniques like organic farming, crop variety, and traditional agriculture, which improve soil health, reduce chemical inputs, and sustain biodiversity (Mishra et al., 2022) which aligns with Sustainable Development Goals (SDGs) 15 (Life on Land), 13 (Climate Action) and 2 (Zero Hunger) (Chao, 2024). Family farms’ varied crop and animal systems are more resilient to climatic shocks, supporting climate adaptation and mitigation efforts. They are essential for food security and sovereignty in accordance with SDGs 2 and 12 (Responsible Consumption and Production), as they stress local control over food systems (Chandana et al., 2022). Family farms contribute to 80 per cent of global food production, contributing to regional and global food systems (Lowder et al., 2021). They also contribute to SDGs 1 (No Poverty) and 8 (Decent Jobs and Economic Growth). Family farms promote social participation, enhance socioeconomic well-being, and reduce hunger and poverty. The productivity and sustainability of family farms depend on agrarian policy, land tenure, and tackling gender inequality (SDG 5). Improving women’s access to resources and decision-making supports resilient rural livelihoods and sustainable family farming.

Research on family farming has increased significantly, but there are challenges, such as need for longitudinal studies, a lack of attention to particular geographical areas and the need to assess the economic feasibility of family farming in light of market integration and globalization (Cecconello et al., 2023). One such example is India. Even though India is home for 24 per cent small holder farmers of the world, research on family farming is still limited because, it is challenging to develop and implement effective interventions tailored to the needs of small family farms and difficulty of reaching and studying this dispersed group. Additionally, the complexity of their diverse farming practices, lack of infrastructure in rural areas, lack of funding for research specifically targeted at smallholders and the belief that research on large-scale farms may be more commercially viable adds up to the challenges (Aubron et al., 2022). Future studies will examine new topics including digital technology, youth engagement, and the relationship between family farming and urban agriculture, in addition to sustainability, climate change adaptation, and food security.

CONCLUSION

The study highlights the evolving landscape of research on family farming, revealing a dynamic and growing field of study in the agricultural sector. With significant contributions from Brazil, Europe and China, the study demonstrates the expanding global interest. From its traditional roots, the focus has shifted towards more holistic and sustainable approaches, encompassing agroecology, gender roles, and rural development policies. Family farming aligns seamlessly with the United Nations' SDGs, particularly in ensuring food security, environmental conservation, and climate action. As research continues to evolve, future directions will explore the integration of digital technologies, youth engagement, and urban-rural agricultural connections, further cementing family farming's vital role in fostering resilient and sustainable food systems worldwide. Ultimately, this transformative field holds immense promise for addressing pressing agricultural challenges and shaping a food-secure future for generations to come.

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Analyzing Perception and Hesitation in the Context of Home Science Career Aspirations

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HIGHLIGHTS

- Stereotypes about home science, peer influence and confusion about career pathways indicating a significant relationship, impact students' perceptions towards choosing home science as a career option.
- Gender bias, limited career knowledge, uncertainty about job opportunities and lack of family support do not have a statistically significant effect on students' perceptions when considering home science as a career option.

ARTICLE INFO

Keywords: Home science, Career, Hesitation, Perceptions, Peer influence, Stereotypes.

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Conflict of Interest: None

Research ethics statement(s):
Informed consent of the participants

ABSTRACT

Home science, despite its rich potential for addressing contemporary societal needs, faces hesitation among prospective students as a viable career option. The study conducted in 2024 on 50 students from several Home Science Educational Institutions. This study adopted a descriptive approach, using structured close-ended questionnaires through quantitative analysis involving interviews and surveys to collect information. This study explored the relationship between students' perceptions of home science as a career option and the factors contributing to their hesitancy in pursuing it. A chi-square analysis was conducted. The findings indicated that stereotypes, peer influence, and confusion about career pathways significantly impact students' perceptions, contributing to hesitation in choosing home science. Conversely, gender bias, limited career knowledge, uncertainty about job opportunities, and lack of family support did not show significant relationships with students' perceptions, indicating that these factors were less influential in their decision to consider home science as a viable career option. These findings highlighted the importance of addressing stereotypes and peer pressure while providing clearer career pathways to improve the perception of home science. The study suggested that targeted interventions in these areas could encourage more students to view home science as a rewarding and viable career choice.

INTRODUCTION

Home science is an interdisciplinary academic field that promotes sustainable living and equips individuals with essential life skills. The discipline merges science and arts, covering subjects like human development, food and nutrition, home management,

community development, and textiles. While home science holds vast career potential, societal perceptions often limit its scope, particularly in countries like India. According to a study by Patel & Kumar (2016), home science is frequently viewed as a field designated for women to enhance household management skills, overshadowing its broader professional opportunities whereas, Employment

empowers women by providing financial independence, alternative source of social identity and exposure to power structures (Priyanka et al., 2019) This perception discourages students from exploring the subject beyond traditional roles. Bhatia & Reddy (2017) observed that many students are unaware of the diverse career paths available within home science, including nutrition, health management, interior design, and fashion technology. Their research pointed out that educational institutions often fail to provide detailed counselling that highlights the dynamic nature of the discipline. It has been noted that professionals and students both frequently choose not to pursue home science as their major career option, despite the field's importance in today's society. Peer pressure also reinforces this hesitancy, as students are reluctant to go against the mainstream preference for more socially acceptable career paths. Kumar & Jain (2018) conducted a study demonstrating that peer and parental influence strongly affects students' career choices. In India, home science is often discouraged by both parents and peers, who perceive it as a less ambitious path compared to fields like engineering or medicine. This pressure further deepens the reluctance among students to choose home science as a profession. Moreover, Rao & Sinha (2020) argued that the lack of modern technological integration and interdisciplinary approaches in home science curricula has made the field less appealing to students. Their study revealed that traditional skills are prioritized over emerging fields like food safety, sustainable textiles, and health management, limiting the relevance of home science in today's job market. A curriculum overhaul is needed to make the field more attractive and aligned with modern employment opportunities. Sharma (2017) observed that societal attitudes still frame home science as a female-centric field, reinforcing gender stereotypes. This perception deters both male and female students from considering home science as a viable career option, negatively impacting enrolment rates. Nair & Bose (2020) noted that while home science graduates find employment in diverse sectors, the field is still perceived to offer limited financial prospects, particularly by middle-class students, who face pressure to pursue higher-earning careers. Das (2021) highlighted that despite its interdisciplinary nature, home science lacks the professional visibility and respect it deserves, particularly in technology-driven industries. In order to promote inclusion and diversity in this area, this course emphasizes the significance of abandoning such preconceptions and encourages people of every gender to investigate and appreciate the subject. This research paper aims to provide in-depth analysis of the relationship of perception of students towards choosing home science as a career option with the factors contributing to their hesitancy in considering it as a career option.

METHODOLOGY

The research was conducted at several Home Science Educational Institutions where this course is offered during the year 2024. This study adopted a descriptive study approach, as it seeks to analyse the relationship of perception of students with the factors contributing to their hesitancy in considering it as a career option. A quantitative method approach was followed to conduct the study. The sample size of 50 students was determined based on the saturation of themes. Purposive sampling was used to select students who have experience or knowledge about home science as

career option. Data was collected from 50 Home Science students using a self-structured, close-ended questionnaire. A questionnaire was administered in the regional language to all selected students. Data was systematically processed, including coding, classification, and tabulation. Frequency analysis and chi-square tests were utilized to analyze the data and draw meaningful conclusions. To analyse the results, the perception of students is treated as the dependent variable i.e., job prospects, career growth, societal recognition. While the various hesitancy factors serve as the independent variables i.e., Stereotypes about home science, Gender bias, Peer influence, limited career knowledge etc. To statistically analyse whether the perception of students (dependent variable) is significantly related to any hesitancy factors (independent variables), Chi-square test was used. The result thus obtained was then analysed and processed in the form of tables.

RESULTS

Perception of students towards choosing home science as a career option and factors of hesitancy

The findings of the Table 1 presents a cross-tabulation of student perceptions with various hesitancy factors related to

Table 1. Cross-tabulation of perception of students and each hesitancy factor

Hesitancy Factors	Positive Perception F(%)	Negative Perception F(%)	Total F(%)
Stereotypes about home science			
Yes	05(10)	09(18)	14(28)
No	25(50)	11(22)	36(72)
Total	30(60)	20(40)	50(100)
Gender Bias			
Yes	04(08)	06(12)	10(20)
No	26(52)	14(28)	40(80)
Total	30(60)	20(40)	50(100)
Peer Influence			
Yes	08(16)	16(32)	24(48)
No	22(44)	04(08)	26(52)
Total	30(60)	20(40)	50(100)
Limited career knowledge			
Yes	07(14)	02(04)	09(18)
No	23(46)	18(36)	41(82)
Total	30(60)	20(40)	50(100)
Uncertainty about job opportunities			
Yes	03(06)	02(04)	05(10)
No	27(54)	18(36)	45(90)
Total	30(60)	20(40)	50(100)
Lack of family support			
Yes	01(02)	02(04)	03(06)
No	29(58)	18(36)	47(94)
Total	30(60)	20(40)	50(100)
Confusion about career pathways			
Yes	04(08)	01(02)	05(10)
No	26(52)	19(38)	45(90)
Total	30(60)	20(40)	50(100)

* F: Frequency

pursuing home science as a career. Each factor was coded as binary (e.g., 1 = “Yes” for presence of the factor, 0 = “No” for absence of the factor). Among students, 28% acknowledged stereotypes, with 10 per cent having positive and 18 per cent having negative perceptions. In contrast, among the 72 per cent students who did not identify stereotypes, 50 per cent had a positive view, and only 22 per cent viewed home science negatively. Out of 20 per cent students who felt gender bias, 08 per cent had positive perceptions and 12 per cent had negative perceptions. Conversely, among 80 per cent students who did not perceive gender bias, the majority (52%) had a positive view, and only 28 per cent had a negative view. Peer influence impacted (48%) students, with a majority (32%) showing negative perceptions. Those (52%) not influenced mostly had a positive view (44%). 18 per cent students indicated limited career knowledge, with a slight majority (14%) having positive perceptions. Most students (46%) did not face this challenge, but a significant portion (36%) still had negative perceptions. Only 10 per cent students expressed uncertainty, and most (6%) had positive perceptions. Among the remaining 90 per cent students, the majority (54%) had positive perceptions. Family support was a minimal concern, with only 6 per cent students affected and the majority (58%) perceiving home science positively. 10 per cent students were confused about career paths, though 8 per cent maintained positive perceptions, while the majority (90%) without confusion leaned towards positive views (52%).

The data in Table 2 highlights the relationship of perception of students towards choosing home science as a career option with the factors contributing to their hesitancy in considering it as a career option. Here’s a detailed breakdown of the results:

Stereotypes about home science: The chi-square value for stereotypes was 4.79, which is greater than the critical value of 3.841 at a 0.05 level of significance. This indicates that stereotypes have a statistically significant impact on students’ perceptions, making it a key factor influencing their hesitancy toward choosing home science as a career.

Peer Influence: The chi-square value for peer influence was 13.67, much higher than the tabulated value of 3.841, demonstrating a strong, significant relationship between peer influence and students’ perception of home science. Peer pressure plays a substantial role in shaping negative perceptions, contributing to students’ hesitancy.

Confusion about career pathways: The chi-square value for confusion about career pathways was 5.37, again higher than the tabulated value of 3.841. This suggests a significant link between uncertainty about career prospects in home science and students’ reluctance to pursue it. Students unclear about career options tend to have negative views or hesitate more when considering home science as a career.

DISCUSSION

The present study highlights the relationship of perception of students towards choosing home science as a career option with the factors contributing to their hesitancy in considering it as a career option. The findings reveal that the field is largely seen as innovative and offering viable career paths, but efforts to further promote it,

Table 2. Calculation of observed and expected frequencies with chi-square

Hesitancy Factors	Positive Perception (χ^2)	Negative Perception (χ^2)	Total Chi-square (χ^2_{total})	Table value (0.05)
Stereotypes about home science				
Yes	O: 05 E: 8.4 $\chi^2 = 1.38$	O: 09 E: 5.6 $\chi^2 = 2.07$	Calculated value 4.79	3.841 d.f. = 1 Significant
No	O:25 E:21.6 $\chi^2 = 0.535$	O:11 E:14.4 $\chi^2 = 0.804$		
Gender Bias				
Yes	O: 04 E: 06 $\chi^2 = 0.67$	O: 06 E: 04 $\chi^2 = 1.0$	Calculated value 2.08	3.841 d.f. = 1 Non-significant
No	O: 26 E: 24 $\chi^2 = 0.167$	O: 14 E: 16 $\chi^2 = 0.25$		
Peer Influence				
Yes	O: 08 E: 14.4 $\chi^2 = 2.844$	O: 16 E: 9.6 $\chi^2 = 4.267$	Calculated value 13.67	3.841 d.f. = 1 Significant
No	O: 22 E: 15.6 $\chi^2 = 2.626$	O: 04 E: 10.4 $\chi^2 = 3.938$		
Limited career knowledge				
Yes	O: 07 E: 5.4 $\chi^2 = 0.474$	O: 02 E: 3.6 $\chi^2 = 0.711$	Calculated value 1.45	3.841 d.f. = 1 Non-significant
No	O: 23 E: 24.6 $\chi^2 = 0.104$	O: 18 E: 16.4 $\chi^2 = 0.156$		
Uncertainty about job opportunities				
Yes	O: 03 E: 03 $\chi^2 = 0$	O: 02 E: 02 $\chi^2 = 0$	Calculated value 0.00	3.841 d.f. = 1 Non-significant
No	O: 27 E: 27 $\chi^2 = 0$	O: 18 E: 18 $\chi^2 = 0$		
Lack of family support				
Yes	O: 01 E: 1.8 $\chi^2 = 0.356$	O: 02 E: 1.2 $\chi^2 = 0.533$	Calculated value 0.95	3.841 d.f. = 1 Non-significant
No	O: 29 E: 28.2 $\chi^2 = 0.023$	O: 18 E: 18.8 $\chi^2 = 0.034$		
Confusion about career pathways				
Yes	O: 04 E: 03 $\chi^2 = 0.333$	O: 01 E: 02 $\chi^2 = 0.5$	Calculated value 5.37	3.841 d.f. = 1 Significant
No	O: 26 E: 27 $\chi^2 = 0.037$	O: 09 E: 18 $\chi^2 = 4.5$		

O: Observed E: Expected Significance level: 0.05

especially among male students and those unfamiliar with its potential, could help address the existing gaps in perception and awareness. The findings show a significant relationship between stereotypes and students' perceptions. Research by Sharma et al., (2021) highlights that stereotype, often associated with gendered views and societal norms discourage students from considering home science. These biases create a perception that home science is a less prestigious or 'female-centric' field, significantly impacting career choices. The significant relationship observed in this study confirms that these stereotypes continue to shape students' hesitancy, aligning with the broader literature on gender and career perceptions. Kaur & Patel (2020) & Arunachalam et al., (2020) also support this finding, showing that students who internalize such gendered views are more likely to disregard home science as a serious career option. The perception that it lacks the rigor and financial rewards of fields like engineering or medicine further deters students. Das (2021) in his study emphasizes that while stereotypes are most commonly observed in rural settings, they also persist in urban educational contexts. The significant relationship found in this study echoes these findings, demonstrating how stereotypes create a substantial barrier to students' willingness to explore home science. Furthermore, Research conducted by Bhasin & Gupta (2021) indicates that one of the key reasons for hesitation in choosing Home Science is the prevailing stereotypes associating the field with traditional gender roles. Home Science is often viewed as a "female-centric" subject, reinforcing the notion that it is limited to domestic skills, which deters students, especially males, from considering it a viable career option. The influence of peers on choosing home science as a career option is a critical factor, especially during adolescence, a period when individuals are highly susceptible to external influences. Peers often play a significant role in shaping students' opinions, aspirations, and perceptions, particularly when it comes to career decisions. Adolescents and young adults are likely to follow the choices made by their friends or classmates, valuing acceptance and fitting in. In many cases, home science may not be perceived as a "mainstream" or "popular field", especially in comparison to more traditionally prestigious courses such as engineering, medicine, or business. As a result, students may hesitate to pursue home science if it is not a favoured option within their social circle. The findings of the study align with the findings of Gupta & Verma (2019); Meinan et al., (2023) who pointed out that peer pressure, especially during adolescence, plays a crucial role in shaping career choices. Students may reject home science due to its lack of popularity or perceived prestige among peers. Previous research emphasizes that peer influence often reinforces negative stereotypes and perceptions of certain fields, which is evident in this study as well, showing how students' decisions are swayed by peer opinion. Further, a study by Singh & Bhatt (2018) points out that peer influence often reinforces existing stereotypes. When a peer group holds the belief that home science is an "inferior" option or primarily for women, these attitudes get magnified, leading to widespread rejection of the field. The present study's findings show that peer influence can outweigh individual preferences, as students may avoid home science out of fear of social alienation or judgment. Baker & Jones in his study (2017) also affirm that peer opinion plays a critical role in

career decision-making, especially in environments where academic choices are closely tied to social status and prestige. The confusion about career pathways as another major factor influences students' perceptions. Previous studies conducted by Joshi in 2020, suggest that students who lack clear information about the career prospects in home science are more hesitant to pursue it. The confusion arises from inadequate career guidance and limited exposure to potential opportunities within the field. This research confirms that students who are unsure of future career paths in home science are more likely to view it unfavourably. Singh et al., (2018) support this by indicating that students who lack guidance or mentorship are less likely to explore non-traditional career paths like home science. Without exposure to the field's potential, students are more prone to confusion and, consequently, hesitation. This confusion is exacerbated by the narrow representation of home science in popular media and education systems, which often fail to showcase the breadth of its applications. The present study's results confirm that this confusion is a significant deterrent, mirroring the conclusions of earlier research that career uncertainty can diminish students' interest in pursuing home science.

CONCLUSION

The present study highlights the relationship between students' perceptions of home science as a career option and the factors contributing to their hesitancy in pursuing it. Despite a generally positive view of the field, although many students recognize the value and potential of home science, a considerable number express reluctance, largely due to societal stereotypes and limited public awareness about its contributions and opportunities. The research highlights the necessity for targeted awareness campaign and educational initiatives aimed at dismantling stereotypes and fostering a supportive peer environment. Moreover, enhancing career counselling and guidance can clarify the pathways within Home Science. By aligning educational strategies with contemporary societal needs and reinforcing its value, more informed, and supportive landscape can be cultivated. Ultimately, this research seeks not only to inform educators but also to inspire students to recognize the rich potential and relevance of Home Science in enhancing quality of life.

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Dimensions and Correlates of Agripreneurial Competency

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HIGHLIGHTS

- Majority of the respondents were having medium level of competency.
- Independent variables like, age, education, annual income, agripreneurial experience were having positive correlation with competency.
- Age and education together contributed 70.4 per cent variation in competency of the respondents.

ARTICLE INFO

Keywords: Agripreneur, Competency, KBK districts, Opportunistic competency, Organising competency, Strategic competency, Commitment competency, Personal competency.

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ABSTRACT

Competency implies that a person with competency possesses the skills and abilities necessary to compete effectively with others. In the present study competency of the agripreneurs measured using the suitable scale in KBK (Kalahandi, Balangir, Koraput, Malkanagiri, Nuapada, Balangir, Sonepur and Raygada) districts of Odisha. State and districts were selected purposively, whereas, respondents were selected randomly. Descriptive research design was followed. Data were collected from the respondents in 2024. A total 17 statements were included under five different dimensions i.e. opportunistic competency, organising competency, strategic competency, commitment competency and personal competency. It was observed that majority of the respondents (63.60%) possessed medium level of competency. It was identified that age, education, annual income and agripreneurial experience were positively associated with their competency level. Further it was noted that, two independent variables age and experience together contributed 70.4 per cent of variance in respondent's competency level.

INTRODUCTION

Agriculture plays a pivotal role in global economies, serving as a cornerstone for food security, employment, and rural development. However, traditional agricultural practices face significant challenges, including climate change, resource depletion, and fluctuating market demands. In this context, agripreneurship emerges as a promising paradigm, merging innovative entrepreneurial strategies with sustainable agricultural practices. Agripreneurship is characterized by its emphasis on creativity and resourcefulness, encouraging individuals to leverage modern technologies and sustainable practices to optimize agricultural production. This integration of entrepreneurship into agriculture presents new opportunities for growth and resilience, particularly in rural areas

where economic diversification is essential. Competency encompasses a combination of knowledge, skills, and attitudes that are essential for effective performance in any field. This definition emphasizes that competencies are dynamic; they can be developed and refined through experiences, training, and coaching (Man et al., 2002; Wagener et al., 2010; Volery et al., 2015; Modak et al., 2018). For entrepreneurs, particularly those leading small businesses, understanding and cultivating these competencies can significantly enhance their ability to navigate challenges and drive growth. Research has shown that a clear grasp of the competencies required for successful entrepreneurship not only supports individual development but also has a direct impact on the overall success of the business (Churchill & Lewis, 1983; Low & MacMillan, 1988; Gupta et al., 2023).

Agripreneurial competency, specifically, refers to the unique set of characteristics-including knowledge, motives, traits, and skills-that facilitate the establishment, sustainability, and expansion of agricultural ventures (Bird, 1995). This competency encompasses a broad spectrum of abilities that allow agripreneurs to effectively respond to market demands, manage resources, and innovate within their fields. Additionally, it can be understood as the total capacity of an entrepreneur to fulfil various roles successfully, which is crucial in a rapidly evolving agricultural landscape (Man et al., 2002). The importance of agripreneurial competencies cannot be overstated, as they directly influence an agripreneur's ability to achieve sustainable growth and success. For instance, a strong understanding of market dynamics allows agripreneurs to identify profitable opportunities and tailor their offerings to meet consumer demands. Furthermore, effective problem-solving and decision-making skills enable them to respond proactively to obstacles, whether they arise from production issues or market competition. By cultivating these competencies, agripreneurs are better positioned to innovate, create value, and contribute positively to the agricultural ecosystem, ensuring not only their own success but also the sustainability of the industry as a whole. Referring to the above-mentioned findings, a humble attempt was made in the study to measure competency level of agripreneurs prevailing in the study area, and association of socio-economic factors with competency was identified and described.

METHODOLOGY

To obtain a thorough understanding of the topic, descriptive research method was adopted. Descriptive research is a type of study that explores the relationships between existing, non-manipulated variables. The research was conducted in specially privileged districts of Odisha, in India, which all together known as KBK districts of Odisha, which includes eight districts as Kalahandi, Nuapada, Koraput, Nawarangpur, Sonapur, Balangir, Raygada & Malkangiri. The scale developed by Maan (2002) was further used for reliability and validity test. The value was 0.87, which was further crosschecked using Spearman's Brown formula and the reliability coefficient was 0.93. The Cronbach alpha value yielded 0.86, which was calculated using SPSS 26, the value indicating high reliability of the instrument. The scale's validity is confirmed through content validity testing. This is achieved when each item, or all items collectively, accurately reflects the intended content to be measured. Since the scale's content is thoroughly supported by relevant literature and expert opinions on agripreneur performance, it is assumed that the scale to measure competency meets the criteria for content validity. Krejci Morgan formula was used to select sample from the population.

$$n = X^2 NP(1-P) / e^2(N-1) + X^2 P(1-P)$$

After selection of sample size proportionate random sampling was used to select sample from various districts for proper representation. A multistage sampling method was employed, incorporating both purposive and random sampling techniques for the study. The final data was collected from 283 agripreneurs (Kalahandi = 49, Balangir = 49, Koraput = 25, Malkangiri = 28, Nuapada = 46, Balangir = 49, Sonapur = 47 and Raygada = 14) in May 2024, by using structured and semi structured interview

schedule. The data were collected, classified, coded, tabulated, analysed and interpreted. Various statistical tools like frequency, percentage, Cumulative Square Root Frequency, correlation coefficient, step-wise regression and chi-square method was used for data analysis.

RESULTS

To measure the competency level of agripreneurs in the study area, the respondents were asked to rate the statements in five-point scale as strongly agree (5), Agree (4), Undecided (3), Disagree (2) and strongly disagree (1). The responses were collected, calculated and tabulated in the Table 1, which pertains the competency level of respondents in the study area.

In the Table 1 first dimension viz. opportunistic competency explained that, more than half of the respondents (55.48% & 76.68%) agreed to the statement that they identify goods and services that customers want. Similarly, 36.40 per cent respondents agreed to the statement that they seize high quality business opportunities, however 35.34 per cent of respondents were undecided about the aforesaid statement.

Organising competency was further explained in the Table 1 that majority of the respondents (44.17%) agreed to the statement organising people is an important aspect in organizational competency. Similarly, 48.76 per cent respondents agreed that organising different resources inside & outside the firm develop organising competency. While, 44.17 per cent respondents strongly agreed that keeping organisation to run smoothly is important for agripreneurs. Whereas 49.82 percentage of respondents agreed to the statements to take remedial actions to solve problem.

It was reported from Table 1 about strategic competency that more than half of the respondents (51.94%) agreed to prioritizing work in alignment with business goals. Likewise, majority of the respondents (49.12%, 37.10% & 49.47%) agreed to the statements aware of project directions and how changes impact the firm, determining strategic actions by weighing costs & benefits and align current actions with strategic goals respectively. Commitment competency was enlisted in Table 1 reflects that 48.76 per cent of respondents agreed to commit long term business goals followed by 29.68 per cent of respondents strongly agreed to that statement. However, 48.06 per cent of respondents agreed to possess an extremely strong internal drive followed by 47 per cent of respondents strongly agreed to that statement.

An overview from Table 1 related to personal competency reflects that 50.18 per cent of respondents agreed to maintain a high energy level followed by 32.51 per cent of respondents who were not sure and made a response of undecided about that statement. Majority of the respondents (31.10%) were undecided to maintain positive attitude followed by 25.80 per cent of respondents who agreed to the above-mentioned statement. Furthermore 49.82 per cent & 35.69 per cent of respondents marked agree and strongly agree to the statement able to work independently. Discussing about the last statement, recognise & work on my own shortcomings 46.29 per cent of respondents agreed, 28.98 per cent of respondent were undecided, followed by 24.38 per cent of respondents, who were strongly agreed to the above-mentioned statement.

Table 1. Categorization of the respondents based on their level of competency about agripreneurship

S.No.	Statements	Response (%)				
		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
I	Opportunistic Competency					
1	Identify goods & services customers want	36.04	55.48	6.01	2.47	0
2	Perceive unmet customer needs	17.67	76.68	5.30	0.35	0
3	Seize high quality business opportunities	10.95	36.40	35.34	17.31	0
II	Organising Competency					
4	Organise people	41.70	44.17	3.89	8.83	1.41
5	Organise different resources inside & outside the firm	42.40	48.76	6.01	2.83	0
6	Keep organisation running smoothly	44.17	41.70	11.66	2.47	0
7	Take remedial actions to solve problem	40.64	49.82	6.01	3.53	0
III	Strategic Competency					
8	Prioritizing work in alignment with business goals	47	51.94	0.71	0.35	0
9	Aware of project directions and how changes impact the firm	44.88	49.12	4.59	1.41	0
10	Determining strategic actions by weighing costs & benefits	18.37	37.10	29.68	14.84	0
11	Align current actions with strategic goals	31.45	49.47	18.37	0.71	0
IV	Commitment Competency					
12	Commit to long term business goals	29.68	48.76	19.08	2.47	0
13	Possess an extremely strong internal drive	47	48.06	3.18	1.77	0
V	Personal Competency					
14	Maintain a high energy level	15.19	50.18	32.51	2.12	0
15	Maintain a positive attitude	14.49	25.80	31.10	23.67	4.95
16	Able to work independently	35.69	49.82	9.54	4.95	0
17	Recognise & work on my own shortcomings	24.38	46.29	28.98	0.35	0

Data collected from informants was classified into low, medium and high category as per the Cumulative Square Root Frequency method. It was revealed that, most of the respondents from the study area (63.60%) belonged to medium level of competency about agripreneurial activities, followed by 20.85 per cent of respondents were in low and 15.55 per cent of respondent were in high competency level.

Analysis of association of competency with independent variables

To find out the association between dependent and independent attributes, Pearson correlation, regression analysis, and chi-square method was applied by using SPSS 26 package. Association among the variables with continuous data type (Interval & Ratio level of measurement) was computed using correlation coefficient and regression while association of variables with categorical type of data (Nominal & Ordinal level of measurement) chi-square analysis was attempted.

Correlation analysis

Independent variables namely age, education, landholding, income, agripreneurial experience, achievement motivation, leadership ability, risk orientation and technical orientation were picked for correlation analysis. results of correlation analysis were portrayed in the below mentioned table.

It is evident from Table 2 that age, education, annal income and agripreneurial experience were positively correlated with competency at 1% level of significance. Likewise, the independent

Table 2. Correlation analysis of selected independent variables with Competency

S.No.	Independent Variable (Interval & Ratio level of measurement)	Pearson Correlation Value	P Value
1	Age	0.826**	0.000
2	Education	0.166**	0.005
3	Operational land holding	-0.210	0.723
4	Annual Income	0.166**	0.005
5	Agripreneurial Experience	0.752**	0.000
6	Achievement motivation	0.028	0.638
7	Leadership ability	0.030	0.615
8	Risk Orientation	0.100	0.094
9	Technical Orientation	-0.037	0.537

** Correlation is significant at the 0.01 level

variables like operational land holding, achievement motivation, leadership ability, risk orientation and technical orientation were having no significant association with competency.

Stepwise regression analysis was conducted to determine the impact of independent variables on competency and to identify the most influential factor in the regression model. This involved initially loading all independent variables into the model and then systematically removing each variable to assess its relative impact on the overall contribution to the dependent variable. As depicted in Table 3 with the R² value of 0.704, it can be inferred that variables such as age and experience significantly influenced the dependent variable. Consequently, they account for 70.4 per cent of the observed variation in the dependent variable.

Table 3. Contribution of independent variables towards competency

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.826 ^a	.683	.682	1.58555	.683	605.020	1	281	.000	
2	.839 ^b	.704	.702	1.53469	.021	19.937	1	280	.000	.924

^aPredictors: (Constant), Age; ^bPredictors: (Constant), Age, Experience; ^cDependent Variable: Competency

Table 4. Chi-square analysis of selected independent variables with competency

S.No.	Independent variable (Nominal and ordinal level of measurement)	Pearson chi-square value	df	P-values
1	Gender	2.920	2	0.232
2	Community attitude	6.082	2	0.048*
3	Information seeking behaviour	44.645	14	0.000**
4	Mass media exposure	19.888	14	0.134
5	ICT utility	12.652	12	0.395

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

Table 4 revealed that community attitude and information seeking behaviour exhibited positive relation with competency, whereas gender, mass media exposure and ICT utility found to had negative relation with competency.

DISCUSSION

The result highlighted that most of the agripreneuers were having medium level of competency, which could be upgraded and enhanced by providing exposure and by developing need-based capacity development programmes. Respondents having low level of competency needs to stressed upon. Tailormade workshops and training programmes can uplift their knowledge, skill and attitude for developing various competencies. Respondents with high competency could act as a key factor for encouraging other agripreneuers by describing their way to success and the successful agripreneuers can work as guiding path for others. Table 1 further discuss that, majority of the respondent agripreneuers were well aware about the agripreneurial competency traits, which were required for their successful performance, the result aligns with Gerli et al., (2011).

Since age was having positive correlation with competency, it can be understood that as the agripreneuers grow older they become more competent in their field. The finding was supported by Pawitan et al., (2018), whereas the finding was in contrast with Venkatesan (2022) and Gnanasaranya & Pranmalai (2018), who reported that age was negatively associated with competency in his study on Socioeconomic effect on Competency. Education provides individuals with knowledge and skills that are essential in their field of study. For example, advanced education in a particular subject area equips individuals with deeper understanding and specialized skills, leading to greater competency in that area. The finding was in line with Umar et al., (2018) & Imo et al., (2024). The variable annual income was found to have positive correlation with competency, Higher income can provide individuals with access to resources, external exposure and enhances the propensity to try various innovations, which ultimately enhances competency. The finding was in line with Vijayalakshmi (2019). Agripreneurial

experience provides practical, hands-on learning opportunities that build skills and expertise. Working directly with agricultural practices, business management, and market strategies helps individuals develop a deep understanding of the field. The finding was supported by Gnanasaranya & Pranmalai (2018). The positive and significant relation between community attitude and competency indicates that a supportive and encouraging community environment can lead to higher levels of competency among its members. This relationship highlights the importance of community values and resources in fostering individual and collective development. The finding was in agreement with Zubair et al., (2021). Individuals who actively engage in seeking and utilizing information tend to achieve higher levels of competency. This relationship highlights the importance of being proactive in acquiring knowledge, staying updated with new developments, and effectively applying information to enhance skills and performance. It can also be highlighted that other variable like operational land holding, achievement orientation, leadership ability risk orientation, technical orientation, gender, mass media exposure and ICT utility were found to have no significant relation with competency. The findings were analogous to Somia et al., (2024); Malebana & Vhukeya (2023), whereas opposed by Akowedaho et al., (2022); Hidayat et al., (2022); Abdullah Alshammari et al., (2023).

The R² value highlights the contribution of important independent and crucial factors, that are contributing the variance of dependent variable. Over time, individuals often advance in their careers, taking on more complex and challenging roles. This progression can lead to the development of higher competency levels. Likewise, experience of the respondents strengthens the capability as respondents became competent with increase of their experience, which ultimately strengthens competency of the agripreneuers. The result as in accordance withZali et al. (2018).

CONCLUSION

Majority of the respondents were found to have medium level of competency, which needs to be upscaled with need-based capacity building programmes, which provides further scope of

improvement in competency level. Independent variables like age, education, annual income, agripreneurial experience, community attitude and information seeking behaviour were found to have positive association with competency of respondents. Among all independent variables, age and agripreneurial experience were contributing major variation on the dependent variable i.e. competency. These findings would be insightful for developing action plan to upscale the competency of agripreneuers, which could be helpful to all the agripreneuers and extension fraternity. There is a scope for further research by increasing sample size, expanding area of study and including related variables to gain comprehensive understanding competency and it's importance for agripreneuers.

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Evaluating the Performance of Cluster Frontline Demonstration (CFLD) on Mustard in North Bengal

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HIGHLIGHTS

- The study evaluated the performance of three improved mustard variety namely PM30, PM 26 and Pusa Vijay in North Bengal.
- The highest yield was observed in Pusa Vijay (18.60 q/ha) followed by PM 26 (17.30 q/ha), PM 30 (13.80 q/ha) and local check B-9 (9.50 q/ha) variety.
- Highest B:C ratio was reported in Pusa Vijay (2.84) followed by PM 26 (2.72), PM 30 (2.57), and local check B-9 (1.85) variety.
- The study proved the effectiveness of extension method i.e. cluster frontline demonstration in promoting new improved varieties among the farming communities.

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ABSTRACT

The production and productivity of mustard in terai and dooars region of North Bengal was comparatively low than national and state average, and farmers were still following decade old varieties and traditional practices. Hence, IARI regional station-Kalimpong promoted advance mustard varieties like PM 30, PM 26 and Pusa Vijay in the region through 600 CFLDs in 6 blocks of Jalpaiguri, Kalimpong and Darjeeling district in North Bengal. The demonstrations were conducted in five consecutive rabi seasons from 2019-2023 and their performance were assessed each year against the control variety. The study used a mix of control- treatment and before-after experimental research design. The findings revealed that the maximum yield was recorded in Pusa Vijay (18.60 q/ha) followed by PM 26 (17.30 q/ha) and PM 30 (13.80 q/ha). The Pusa Vijay reported yield advantage of 48.92 per cent followed by PM 26 (45.09%) and PM-30 (31.16%). The study proved the effectiveness of CFLD in speedy outspread of suggested technologies of mustard horizontally among the farming communities. So, it is recommended that policy bodies should come up with sufficient financial support to frontline extension system for conducting CFLD under the guidance of scientists and extension professionals.

INTRODUCTION

Mustard (*Brassica species*) is one of the most important oilseed crops in India, contributing significantly to the country's agricultural economy and food security. Despite being the largest producers of oilseeds in the world, India imports about half of its

demand because of changing lifestyle in dietary pattern and enhanced per capita income. The rise in production of domestic edible oils has not been able to keep pace with the rise in consumption and the difference between production and consumption is being fulfilled through imports. In India, Mustard was grown over 6.69 million hectares area with a productivity of 1511 kg ha⁻¹ (Directorate of

Economics & Statistics, 2021). With the rising demand for edible oils and the challenges posed by climate change, pests, and diseases, the adoption of improved mustard varieties has become crucial for enhancing its production. The adoption of improved mustard varieties is not just a matter of agricultural advancement; it is essential for ensuring food security, economic stability, and sustainable farming practices in India. But, many farmers still rely on traditional mustard varieties, which often have lower yields compared to improved varieties. Traditional mustard varieties often suffer from lower yields, typically ranging between 800 to 1,200 kg per hectare. In contrast, improved mustard varieties have been developed through modern breeding techniques, offering yields of up to 2,500 kg per hectare or more. By adopting these improved varieties, farmers can significantly increase their productivity, ensuring better income and livelihood. However, the adoption of high-yielding and disease-resistant hybrids is not widespread specially in North Bengal due to lack of awareness, access, and financial constraints. All though the agricultural research have made much progress in advancement of the production technologies of the mustard crop, the farming community of Terai region of North Bengal is yet to utilize the benefits of these developments (Barma et al., 2021). Therefore, IARI Regional station-Kalimpong, took an initiative to introduce the different improved variety of mustard through cluster frontline demonstrations to increase the production and productivity of mustard crop in the region.

METHODOLOGY

The CFLDs were conducted in Maynaguri and Dhupguri block of Jalpaiguri district, Kalimpong I block and Gorubathan block of Kalimpong district, Kurseong and Khoribari block of Darjeeling district. The demonstrations were conducted in five consecutive rabi seasons from 2019-2023 in these six blocks. A mix of experimental (control- treatment and before-after) and ex-post factor research design was used for the present study. The experimental design was used for the variable in which direct manipulation was done, and ex-post-facto design was used where direct manipulation of variable was not possible. Initially, a baseline survey was done in all the blocks to know the existing cultivation practises of the mustard growers. A total of 600 mustard farmers with total land holding of 400 ha. were selected using purposive sampling for conducting the CFLDs as per the interest and risk bearing capacity of the farmers. The farmer's current mustard cultivation practises were treated as the local check plot. In identified plots for CFLDs, the suggested package of practises was adopted for growing the mustard. Prior training programme was conducted to expose the farmers toward new technology before demonstration. The demonstrations were laid out preferably in an area near to the roads where both recommended as well as local varieties can be grown for better comparison. The data on crop yields, growth parameters and morphological parameters were immediately collected both from the check plots as well as the demonstration plots to identify the yield gaps. The economic performance of each variety was calculated taking the inputs' prevailing market prices for the particular year (2024). The effectiveness of the CFLDs was calculated by the formula of Samui et al., (2000). The structured interview schedule was used to collect information on the adoption

of recommended technologies, varietal replacement, and horizontal spread of recommended variety. The extension gap, technology gap, technology index along with the benefit cost ratio (BC ratio) were worked out using the following formula:

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - Farmer's yield

Technology index = Technology gap / Potential yield X 100

RESULTS

Current production and productivity of mustard in the region

The findings in Table 1 revealed that the production and yield of all the three districts namely Jalpaiguri, Darjeeling and Kalimpong was quite low in comparison to national and state average. The area in Jalpaiguri district declined from 9170 ha in 2013 to 4600 ha by 2018. The production also declines from 6009 tonnes in 2013 to 4369 tonnes by 2018. The average yield of the district varied between 0.60 tonnes/ha to 0.96 tonnes/ha which was very low in comparison to national and state average. In Darjeeling, maximum area under rapeseed and mustard was recorded in 2022 (435 ha) and lowest area of 333 ha was recorded in 2020. The production of only 111 tonne was recorded in 2014 with a productivity of 0.30 tonnes/ha. The average productivity in the district varied between as low as 1.26 tonnes/ha to 0.78 tonnes/ha. In Kalimpong, the area under rapeseed and mustard varied from 92 ha in 2018 to 2017 ha in 2022. Highest production of 289 tonne was recorded in 2022 while the lowest production of 75 tonne was reported in 2019. The lowest productivity was reported in 2019 (0.62 tonne/ha). However, the average productivity made a significant jump in 2022 (1.4 tonne/ha). The poor production and productivity scenario in all these districts indicates the existing technological gap and need for adoption of improved technologies for enhancing the production and productivity in mustard crop.

Details of technological interventions

The performance of demonstrated variety was compared with the local popular variety to assess the superiority of selected technology. The major inputs for demonstration were supplied to the farmers by the IARI Regional station, Kalimpong. Other inputs like fertilizers, pesticides, herbicides and irrigation were managed by the farmers themselves as per the suggestions of scientists of IARI. The mustard variety were sown during first week of November with a seed rate of 5-6 kg/ha in furrows with 30 cm row spacing using seed drill. The seed was treated with carbendazim @ 2 g/kg of seed or mancozeb @ 2g/kg. Application of N, P, K and S @ 80 kg, 40 kg, 30 kg and 40 kg/ha were followed in demonstration plot. Split application of N @ 50% and full dose of P and K as basal and remaining 50% dose of N were applied at the time of flowering stage. Phosphogypsum was applied two days before seed sowing. Two irrigation-one at the time of flowering and second one during pod formation i.e. 65-70 days after sowing were followed by the selected farmers. The CFLD farmers followed pre-emergence application of pendimethalin (30EC) @ 3.3 l/ha to control weed in mustard field and spraying of imidacloprid 17.8 SL @ 0.2 ml/l water to protect the crop against aphid problem. In control plot, the fields

Table 1. District-wise area, production and yield of rapeseed and mustard from 2013-2022

Year	Jalpaiguri			Darjeeling			Kalimpong		
	Area (ha)	Production (tonne)	Yield (t/ha)	Area (ha)	Production (tonne)	Yield (t/ha)	Area (ha)	Production (tonne)	Yield (t/ha)
2022	5959	5483	0.92	435	254	0.58	207	289	1.4
2021	5692	5466	0.96	336	262	0.78	113	101	0.89
2020	5676	5109	0.90	333	240	0.72	111	82	0.74
2019	5658	4727	0.84	336	424	1.26	116	75	0.65
2018	4600	4369	0.95	427	173	0.41	92	57	0.62
2017	5453	4953	0.91	368	129	0.35	-	-	-
2016	2594	1759	0.68	375	189	0.5	-	-	-
2015	7535	5412	0.72	450	214	0.48	-	-	-
2014	7754	4640	0.60	365	111	0.3	-	-	-
2013	9170	6009	0.66	400	260	0.65	-	-	-

Source: Ministry of agriculture & farmers welfare, Government of India

Table 2. Details of technological interventions in CFLD practices vs. traditional farmers practices

Particulars	CFLD	Farmers Practices
Farming situation	Rainfed	Rainfed
Variety	PM-30, PM-26 and Pusa Vijay	B-9
Seed treatment	Seed treatment with carbendazim @ 2 g/kg of seed or mancozeb @ 2 g/kg seed	Nil
Time of sowing	The first week of November for early sowing variety and mid-November for late sown variety like PM 26	Last of week of November to first fortnight of December
Method of sowing	Line sowing using seed driller	Broadcasting
Spacing	30*10 cm	No specific spacing was maintained
Irrigation	Two irrigation-one at the time of flowering and second one during pod formation i.e. 65-70 days after sowing	Nil
Weeding	Pre-emergence application of pendimethalin (30EC) @ 3.3 l/ha	Nil
Seed rate	5-6 kg/ha	8-10 kg/ha
Fertilizer dose	Application of N, P, K and S @ 80 kg, 40 kg, 30 kg and 40 kg/ha, and application of N in two split doses.	80 kg N and 40 kg P
Plant protection measurement	Spraying of imidacloprid 17.8 SL @ 0.2 ml/l water to protect the crop against aphid problem.	Nil

were managed by the farmers as per their own traditional farming practices. Irrigation and seed management was done as per the actual need in field condition. Finally, one field day was conducted involving all the farmers, scientists, officials from State Department of Agriculture, local extension workers to demonstrate the superiority of technology.

Impact on growth and yield attributes

The findings of growth and yield parameters of mustard crop revealed that the maximum plant height was recorded in PM 30 variety (185 cm) followed by Pusa Vijay (184 cm), PM26 (170 cm) and control variety B-9 (105 cm). Highest number of siliqua per plant was recorded in Pusa Vijay variety (239) followed by PM 26 (105), B- 9(91) and PM-30 (85). The maximum number of seed per siliqua was recorded in PM 26 variety (14) followed by

Pusa Vijay (13), PM-30 (12), and B-9 (10). The highest siliqua length was observed in PM 30(4.80 cm) followed by PM-26 (4.80 cm), B-9 (4.70 cm) and Pusa Vijay (4.55 cm). The maximum oil content was found in PM 30 and Pusa Vijay (35%) while minimum oil content was observed in PM 26 (33%) variety of mustard. Highest test weight was 4.88 g in PM 30 variety of mustard whereas the lowest test weight was 3.20 g in B-9 variety of mustard. The longest maturity period was recorded in Pusa Vijay variety (145 days) while the shortest maturity period was observed in B-9 variety (90 days) of mustard.

Performance of mustard crop and gap analysis

The average yield of 13.80 q/ha was observed in case of PM-30 variety in demonstration plot. The variety has a yield advantage of 31.16 per cent against the local check variety. The extension gap

Table 3. Growth and yield attributes of mustard varieties under CFLD and control plot

Variety	Plant height (cm)	Siliqua/plant	Oil content (%)	Seed/siliqua	Siliqua length (cm)	Test weight (g)	Maturity
PM 30	185	85	35	12	4.80	4.88	137
PM 26	170	105	33	14	4.80	3.45	126
Pusa Vijay	184	239	35	13	4.55	4.80	145
Farmers control-B9	105	91	34	10	4.70	3.20	90

Table 4. Evaluation of yield performance of different mustard varieties

Variety	Potential yield (q/ha)	CFLD plots (q/ha)	Local check plots (q/ha)	% increase over local check plots	Z-value	Extension gap (q/ha)	Technological gap (q/ha)	Technology index
PM 30	18.24	13.80	9.50	31.16	3.13*	4.30	4.44	24.34
PM 26	22	17.30	9.50	45.09	7.26**	7.80	4.70	21.36
Pusa Vijay	25	18.60	9.50	48.92	7.98**	9.10	6.40	25.60

**Significant at 1% level, *Significant at 5% level

of 4.30 q/ha and technological gap of 4.44 q/ha was observed. The average yield of PM 26 variety was 17.30 q/ha and had a yield advantage of 45.09 per cent over its local counterpart. The extension gap of 7.80 q/ha and technological gap of 4.70 q/ha indicates the unexplored potential of the variety. The variety Pusa Vijay recorded an average yield of 18.60 q/ha with a yield advantage of 48.92% over its local counterpart. This variety recorded highest extension gap of 9.10 q/ha and technological gap of 6.40 q/ha.

Increased rate of adoption

The findings on adoption of different mustard growing technologies and practices revealed a significant increase in the adoption of recommended technologies after CFLD in the adopted villages. It is found that earlier only 86 farmers adopted any IARI mustard varieties in the region which increased to 538 farmers with an increase of 84.01 per cent and difference was significant at 1% level of significance ($t=5.31$). Maximum 88.25 per cent increase in adoption of recommended seed rate ($t=5.89$) was reported followed by weed management (87.14%), farm mechanization (85.36%, $t=4.70$) and seed treatment practices (84.08%, $t=4.62$). Other significant technological adoption was reported in case of nutrient management practices (83.11%, $t=3.76$), plant protection management (82.93%, $t=2.90$), sowing time (82.89%, $t=3.53$) and irrigation management (82.46%, $t=1.96$).

Decline in pest and disease incidence

The recommendation under CFLD to control pest and diseases in mustard field has helped to lower down the incidence of major pest and disease problem in the region. Only 5 per cent farmers reported about stem rot problem in their field under CFLD while 15 per cent farmers from the control village reported about the same in their mustard field. The problem of aphid was reported by only 7 per cent farmers who participated in CFLD while 25 per cent farmers from the control village reported about the aphid problem in their mustard field. The problem of powdery mildew was

reported by 8 per cent farmers from the treatment village against 30 per cent farmers from the control village. The application of recommended pesticides like imidacloprid helped to control the menace of aphid problem in mustard field under CFLD. This indicates the effectiveness of CFLD in controlling the pest and disease in the mustard field.

Impact of CFLD on horizontal spread

The CFLD conducted for introduction of new mustard varieties gained quick popularity among the farming communities. In 2019, only 70 farmers adopted the IARI mustard varieties in 35 ha area. In 2020, 46.15 per cent more farmers ($f=130$) adopted the IARI mustard varieties and cultivated in 86 ha area. In 2021, total 221 farmers adopted the variety which was 41.18 per cent more than the previous year and total 110 ha area was brought under IARI variety. In 2022, 28.71 per cent more farmers adopted the variety in 200 ha area which was 45 per cent more than the previous year. In 2023, total 400 farmers adopted the IARI mustard variety in 315 ha area which was 36.51 per cent more than the previous year.

Impact on income

The economics of mustard production under cluster frontline demonstration was calculated and the result of the study has been given in Table 7. The inputs and outputs prices of commodities prevailed during the study were taken for calculating gross return,

Table 6. Horizontal diffusion of IARI mustard varieties

Year	No. of farmers adopted	Change in Area (ha)	% Change in no. of farmers	% change in area
2019	70	35	0	0
2020	130	86	46.15	59.30
2021	221	110	41.18	21.82
2022	310	200	28.71	45.00
2023	400	315	22.50	36.51

Table 5. Technology adoption in mustard

Technology/practices	Before CFLD	After CFLD	% change	t-test
Adoption of IARI mustard variety	86	538	84.01	5.31*
Seed rate	53	451	88.25	5.89*
Seed treatment practices	75	471	84.08	4.62*
Sowing time	51	298	82.89	3.53**
Nutrient management practices	65	385	83.11	3.76**
Plant protection management	70	410	82.93	2.90**
Farm mechanization	47	321	85.36	4.70*
Irrigation management	50	285	82.46	1.96**
Weed management	63	490	87.14	4.65*

*Significant at 1% level of significance, **Significant at 5% level of significance

Table 7. Economic advantage of IARI mustard varieties

Particular	Average Cost of cultivation (Rs./ha)	Average gross return (Rs./ha)	Average Net return (Rs./ha)	Benefit cost ratio
PM 30	25200	90000	64800	2.57
PM 26	25500	95000	69500	2.72
Pusa Vijay	26000	100000	74000	2.84
B 9	24200	45000	20800	1.85

cost of cultivation, net return and benefit : cost ratio. The average cost of cultivation was calculated for both demonstration plot and control plot to understand the economic feasibility of CFLD variety in the region. The total average operational cost in demonstration plot was Rs. 25200/ha whereas in control plot it was Rs. 24200/ha. Though farmers' cost of cultivation in demonstration plot was marginally higher than the control plot but the yield and profit from demonstration plot was much higher than the control plot. The average gross return in demonstration plot of PM-30 was Rs. 90,000/ha whereas in control plot it was only Rs. 45,000/ha. The average net return in demonstration plot was Rs. 64800/ha, much higher than the control plot (Rs. 20,800 /ha). The B:C ration in demonstration plot was 2.57 while in control plot it was 1.85. the highest B:C ration of 2.84 was reported in demonstration plot of Pusa Vijay with average gross return of Rs.100000/ha and average net return of Rs. 74000/ha. The B:C ratio of PM-26 variety was 2.72 with average gross return of Rs. 95000/ha and average net return of Rs. 69500/ha. So, all these findings indicate the better potential of higher profitability of IARI mustard varieties than the traditional mustard varieties. Therefore, the farmers should adopt the new improved recommended mustard varieties based on their cropping pattern and land type for better production and productivity.

DISCUSSION

The findings of growth and yield parameters of mustard crop revealed that the maximum plant height was recorded in PM 30 variety (185 cm) followed by Pusa Vijay (184 cm), PM 26 (170 cm) and control variety B-9 (105 cm). A plant's height is controlled by genetical characteristics, and different varieties will grow to varying heights depending on their genetic make-up in a given environment (Dongarkar et al., 2005). Highest number of siliqua per plant was recorded in Pusa Vijay variety (239) followed by PM 26 (105), B-9 (91) and PM-30 (85). The number of siliqua varies between kinds, which could be attributable to genetic variation (Kumar et al., 2018; Biswas et al., 2019). Number of seeds per plant is one of the most significant criterion in yield attributes and the rapeseed-mustard varieties under testing differ significantly in terms of number of seeds per siliqua. The maximum number of seed per siliqua was recorded in PM 26 variety (14) followed by Pusa Vijay (13), PM-30 (12) and B-9 (10). The highest siliqua length was observed in PM 30 (4.80 cm) followed by PM-26 (4.80 cm), B-9 (4,70 cm) and Pusa Vijay (4.55 cm). The observed variation in the number of seeds/siliqua for different mustard varieties could be attributable to the photoperiodic response of the rapeseed-mustard to day-length duration. The maximum oil content was found in PM 30 and Pusa Vijay (35%) while minimum oil content was observed in PM 26 (33%) variety of mustard. Highest test weight was 4.88 g in PM 30 variety of mustard whereas the lowest test weight was

3.18 g in PM 28 variety of mustard. Test weight (1000 Seed weight) of grains varied significantly mainly due to the effects of variety. The weight of 1000 seeds differ from variety to variety and species to species (Mondal et al., 1992). The longest maturity period was recorded in Pusa Vijay variety (145 days) while the shortest maturity period was observed in B-9 variety (90 days) of mustard. Dkhar et al., (2022) in their study reported about plant height of 89.30 cm in PM-26 variety with 7.03 branches, 111.50 siliqua per plant, 4.81 cm siliqua length, 11.75 number of seeds per siliqua, 40.30 per cent oil content. The findings are in line with the present study. It's possible that the influence of cumulative favourable effects of crop characteristics like number of branches/plants, siliqua/plant, and seeds/siliqua contribute to higher yield by different varieties (Helal et al., 2016). Singh et al., (2023) reported that the cultivation of PM-30 variety of mustard gave higher net returns of Rs. 32135 and Rs. 47350/ha in 2021-22 and 2022-23 respectively with B:C ration of 2.77 and 3 respectively. The results are in conformity with the findings of Jha et al., (2021). The B:C ratio of 2.79 was reported by Kumar (2022) in his study in south-eastern plate of Jharkhand. All these findings highlight the need of improved variety selection to enhance the production and productivity of mustard crop in North Bengal.

CONCLUSION

The cluster frontline line demonstrations (CFLDs) conducted by IARI Regional station-Kalimpong had contributed significantly to enhance the yield of mustard and helped to spread recommended technologies among the farming communities through different extension activities under CFLD programmes. The study proved that the potential yield of mustard varieties can be realized by imparting scientific knowledge to the farmers, making available the need-based quality inputs and their proper utilization. The demonstration trails also enhanced the relationship among different stakeholders and built up the confidence among the farmers about new mustard growing technologies. The participant farmers of CFLD also played an important role in wider dissemination of the improved varieties of mustard to the nearby farmers. Therefore, it is suggested that policy maker should provide sufficient financial support to the frontline extension system for timely planning and organizing CFLD for promoting such new varietal technologies in mustard to lower down its dependency on import of edible oil.

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Drivers of IPM Adoption among Hybrid Tomato Farmers in Karnataka: Insights through Mlogit Model

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HIGHLIGHTS

- Cultural and chemical practices were found to be more prevalent in IPM practices than physical and biological practices regarding hybrid tomatoes.
- In the MLR model, Nagelkerke's R-square revealed that selected explanatory variables explained 60.90 per cent of variations in the adoption level of IPM practices.
- MLR model identified factors influencing the adoption of IPM were age ($p=0.021$), education ($p=0.022$), Extension contact ($p=0.013$), and cosmopolitaness ($p=0.029$).

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ABSTRACT

The investigation was undertaken during 2020 to study the adoption level of IPM practices and the factors influencing adoption among hybrid tomato growers in Karnataka as such studies are scanty in India despite 60 per cent market share of hybrid tomato. Primary data were collected using a structured interview schedule by personally interviewing 120 respondents. Findings revealed that cultural practices like crop rotation, exhibited higher adoption rates, while biological methods were relatively less adopted. Overall, IPM adoption remained limited, with only a small proportion of growers fully embracing these practices. Multinomial logistic regression (MLR) had Nagelkerke's R-square or Pseudo R^2 value of 0.609, indicating 60.90 per cent of total variations in the adoption level of IPM practices, explained by selected explanatory variables. Further, MLR identified factors significantly influencing the adoption of IPM were age ($p=0.021$), education ($p=0.022$), Extension contact ($p=0.013$), and cosmopolitaness ($p=0.029$) (odds ratio [OR], 6.707; 95% CI of OR 1.211 to 37.158) found significant at 5% level ($p<0.05$); while social participation ($p=0.076$) was found significant at 10 per cent level ($p<0.10$). Targeted interventions and training programmes are needed to promote sustainable practices, particularly among hybrid tomato growers, addressing barriers and enhancing the adoption of IPM practices.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) ranks as the fourth most economically significant food crop globally and is cultivated across nearly all countries (Schreinemachers et al., 2018). India contributes 11 per cent of the world's total tomato production, making it the

second-largest producer after China (FAO, 2020). However, tomato plants are highly vulnerable to a wide range of insect pests and plant diseases, collectively referred to as "pests", posing a continuous challenge for farmers to safeguard their crops effectively. NIFA (2023) reported that pests cause extensive damage to other agricultural products across the globe accounts 20-40 per cent

annually, whereas about 30-35 per cent annual yield loss in India (The Hindu, Feb. 25; 2017). Due to poor knowledge, farmers often resort to using excessive and imbalanced amounts of chemical pesticides to safeguard their crops (Depenbusch et al., 2023). The farmers need information about IPM practices on the utmost prominence for sustainable and effective management of pests (Shukla et al., 2024a). Since the last three decades, pesticide use has increased almost a couple of fold worldwide. Globally, the application of pesticides per area of cropland is 1.8 kg ha⁻¹, and India is one of the top ten (Globally, 9th rank) pesticide consumer countries in the world (FAO, 2022). While chemical pesticides are widely recognised for their effectiveness, their indiscriminate use harms beneficial insects, non-target plants, soil, and the environment, as well as the presence of residues in food products, which pose risks to human health too (Mancini et al., 2005; Stehle & Schulz, 2015; Kariathi et al., 2016). So, the realisation has set that the use of solely synthetic pesticides is not economically and environmentally sound for controlling pests. Deleterious effects of chemical pesticides on human health and the ecosystem have forced agriculturists to look at IPM which is a harmonious integration of cultural practices, plant products-based formulations, and bio-agents (Kogan, 1998) for lessening the quantum of deadly pesticides. This method is considered to be economical, effective, practical, protective, and eco-friendly.

Narayanaswamy et al., (2013) reported that adoption of IPM practices among the Tomato farmers in Karnataka brought the benefit cost ratio increased from 1.7 to 2.3 as compared to non-adaptor of IPM practices. The yield was also obtained 18.2 tons acre⁻¹ by IPM adopter farmers as compared to 16.1 tons acre⁻¹ in non-IPM farmers. Despite its technical and economic advantages and its environmentally friendly approach compared to conventional chemical methods, IPM adoption remains limited to just about 2% of the area treated with plant protection inputs (Rao & Rao, 2010). So, the present study investigation was undertaken to study the adoption level of IPM practices among hybrid tomato growers as such studies are scanty in India despite 60 per cent of hybrid tomato market share.

METHODOLOGY

An ex-post facto study was conducted to measure the adoption level of IPM practices (Srivastava et al., 2024) and its socio-economic determinants among hybrid tomato growers in the Kolar district of Karnataka in 2020. The Kolar district was purposely selected as the district occupied first position both in area and production of tomatoes among the districts of Karnataka. Two blocks of the Kolar district namely Srinivasapura and Mulbagal; and three villages from each selected block were chosen through a simple random sampling method. Furthermore, from each selected village, 20 respondents were selected on a random basis. Thus, a total sample constituted 120 respondents (hybrid tomato growers) for the study purpose. Primary data were collected from respondents by personally interviewing the respondents with the help of a structured interview schedule.

The adoption of IPM practices by respondents was assessed using an interview schedule comprising 29 questions categorised into four groups: i) Cultural control, ii) Mechanical control, iii)

Chemical control, and iv) Biological control. Responses were quantified by assigning scores of “2” for full adoption, “1” for partial adoption, and “0” for non-adoption. The adoption score for each statement was determined using the following formula Chattopadhyay & Pareek (1967):

$$\text{Adoption scores} = \sum n_2 \times 2 + \sum n_1 \times 1 + \sum n_0 \times 0$$

Where, n_2 = number of items belonging to the full adoption category

n_1 = number of items belonging to the partial adoption category

n_0 = number of items belongs the non-adoption category

Based on obtained adoption score, respondents were categorised as fully adopted, partially adopted, and not adopted adoption categories using the arithmetic mean (\bar{x}) and standard deviation (σ). The overall adoption score was computed by obtaining the average adoption score of all four sub-categories. A multinomial logistic regression model was used for analysing the determinants of the adoption level of IPM practices among hybrid tomato growers. It is used when the responses of the dependent variable have more than two nominal categories (namely fully adopted, partially adopted, and not adopted). In the social science research, the major advantage of using multinomial logistic regression over multiple linear regression is, prior does not require continuous and numerically normal distribution of data (Petrucci, 2009; Kumari, et al., 2022; Kumar & Lahiri, 2023; Verma, et al., 2023).

RESULTS

Adoption level of cultural practices by hybrid tomato cultivators

Table 1(a) provides an overview of the adoption of various cultural practices among tomato growers, along with the total adoption score. Among the various IPM practices listed under the cultural practices category, summer ploughing garnered a mixed response, with 3.33 per cent of farmers fully adopting it, 75 per cent partially adopting it, and 21.67 per cent not adopting it. Timely removal and destruction of tomato stubbles and burning of residues saw higher partial adoption at 60 per cent, with 15.83 per cent fully adopting it. Non-stocking of diseased plants near the field received a relatively balanced response, with 25 per cent fully adopting it, 37.50 per cent partially adopting it, and the same percentage not adopting it. Notably, practices like the non-burning of LDPE mulch papers and the use of photodegradable and biodegradable plastic mulch showed lower adoption rates overall. Crop rotation with different crops and stacking immediately after flowering with support sticks had relatively higher levels of adoption, with 26.67 per cent and 28.33 per cent fully adopting them, respectively.

Adoption level of physical/mechanical practices by hybrid tomato cultivators

Table 1(b) outlines the adoption levels of various physical and mechanical practices employed by tomato growers along with the total adoption score. Rouging of plants affected by bacterial wilt exhibited relatively low adoption rates, with only 6.67 per cent of farmers fully adopting it, while 21.67 per cent partially adopted

Table 1. Practice-wise Adoption of IPM methods by hybrid Tomato cultivators

S.No.	Cultural Practices	Adoption			Total Adoption Score
		FA (%)	PA (%)	NA (%)	
1.a)					
1	Summer ploughing	3.33	75.00	21.67	98
2	Timely removal and destruction of tomato stubbles and burning of residues	15.83	60.00	24.17	110
3	Non-stocking of diseased plants near the field	25.00	37.50	37.50	105
4	Non-burning of LDPE mulch papers	3.33	20.83	75.84	33
5	Photodegradable and biodegradable plastic mulch	1.67	20.83	77.50	29
6	Different trap crops grown in hybrid tomato (Marigold, Maize, Cucumber, Cowpea)	3.33	25.00	71.67	38
7	Crop-rotation with different crops like (Beans, Field Bean, Capsicum, Chilli)	26.67	38.33	35.00	110
8	Different Intercrops grow in hybrid tomato crops (Okra, Onion, Radish)	7.50	46.67	45.83	74
9	Stacking immediately after flowering with the help of eucalyptus/bamboo sticks	28.33	38.33	33.34	114
1.b) Physical/Mechanical Practices					
1	Rouging of plants affected by bacterial wilt	6.67	21.67	71.66	42
2	Use of yellow sticky traps to control white flies	15.00	26.67	58.33	68
3	Use of flower model traps to control thrips	2.50	7.50	90.00	15
4	Use of mulching with black low-density polyethylene (LDPE) sheet to control weed growth and conserve moisture	8.33	58.33	33.34	90
5	Use of biodegradable plastic mulch which increases fruit yield and quality	4.17	5.00	90.83	16
6	Use of light traps (2 units acre ⁻¹)	4.17	4.17	91.66	15
7	Use of green nylon net around hybrid tomato field to control white flies	20.83	25.00	54.17	80
8	Use of methyl eugenol pheromone trap to control fruit flies	12.50	35.00	52.50	72
1.c) Chemical Practices					
1	Different Systemic fungicides (To control Late Blight)	40.83	39.17	20.00	145
2	Different systemic and contact fungicides	12.50	59.17	28.33	101
3	Different insecticides (To control chewing and sucking pests)	36.67	20.83	42.50	113
4	Different systemic and contact insecticides	14.17	51.67	34.17	96
5	Selective and non-selective herbicides (To control weeds)	15.00	8.33	76.67	46
6	ETL of pest control	2.50	12.50	85.00	21
1.d) Biological Practices					
1	Use of larval parasite like (<i>Bracon spp</i> , <i>Ichneumon spp</i> , <i>Campoletis spp</i>)	0.83	0.83	1198.34	3
2	Use of egg parasitoids like (<i>Trichogramma spp</i> , <i>Tetrastichusspp</i> , <i>Telonomus spp</i>)	1.67	2.50	95.83	7
3	Use of predators like (Red ants, Dragonfly, Ladybird beetle)	0.83	0.83	98.34	3
4	Grow pulses or cow peas on the bunds to build natural enemy fauna	20.00	8.33	51.67	82
5	NPV (<i>Nuclear Polyhedrosis Virus</i>) 100 LE /acre	0.00	0.83	99.17	1
6	Seed treatment with <i>Trichoderma viride/ Trichoderma harzianum</i> (2g/100gm seed)	2.50	3.33	94.17	10

FA=Full Adoption; PA=Partial Adoption; NA=Non-Adoption

it, and 71.66 per cent did not adopt it. Similarly, the use of yellow sticky traps for controlling white flies saw moderate adoption, with 15 per cent fully adopting it and 26.67 per cent partially adopting it. Conversely, practices like using flower model traps for thrips control and employing light traps showed limited adoption, with the majority of farmers not utilizing these methods. Mulching with black low-density polyethylene (LDPE) sheets for weed control and moisture conservation had moderate adoption, with 8.33 per cent fully adopting it and 58.33 per cent partially adopting it. Adoption rates were notably low for the use of biodegradable plastic mulch and light traps. However, the use of green nylon nets around hybrid tomato fields for white fly control and methyl eugenol pheromone had relatively higher adoption rates, with 20.83 per cent and 12.50 per cent of farmers fully adopting them, respectively.

Practice-wise adoption level of chemicals by hybrid tomato cultivators

Table 1(c) provides insights into the adoption rates of various chemical practices employed by tomato farmers, alongside the total adoption score. For controlling late blight, different systemic fungicides such as Dimethomorph, Tebuconazole, Metalaxyl, and Tricyclazole combined with Hexaconazole showed relatively high adoption rates, with 40.83 per cent fully adopting and 39.17 per cent partially adopting them. Conversely, practices involving systemic and contact fungicides saw moderate adoption, with Metalaxyl combined with Mancozeb and Tricyclazole combined with Mancozeb exhibiting 12.50 per cent full adoption and 59.17 per cent partial adoption. In terms of insecticide usage for chewing and sucking pest control, various options like Acephate, Fipronil,

Spinosad, Abamectin, Lambda-cyhalothrin, Thiamethoxam, and Imidacloprid were employed, with 36.67 per cent fully adopting and 20.83 per cent partially adopting them. Similarly, systemic and contact insecticides, including Beta cyfluthrin combined with Imidacloprid and Fipronil combined with Imidacloprid, demonstrated moderate adoption rates, with 14.17 per cent fully adopting and 51.67 per cent partially adopting them. Selective and non-selective herbicides for weed control, such as Metribuzin, Oxyfluorfen, Paraquat Dichloride, and Glyphosate, showed varying adoption rates, with 15 per cent fully adopting and 8.33 per cent partially adopting them. Additionally, the concept of Economic Threshold Level (ETL) for pest control exhibited low adoption rates, with only 2.50 per cent fully adopting it and 12.50 per cent partially adopting it.

Adoption level of biological practices by hybrid tomato cultivators

Table 1(d) outlines the adoption rates of various biological practices utilised by tomato farmers, alongside the total adoption score. Adoption of larval parasites like *Bracon spp.*, *Ichneumon spp.*, and *Campoletis spp.* were minimal, with only 0.83 per cent fully adopting and 0.83 per cent partially adopting them, while the majority, accounting for 98.34%, did not adopt these practices. Similarly, the use of egg parasitoids such as *Trichogramma spp.*, *Tetrastichus spp.*, and *Telonomus spp.* showed limited adoption, with 1.67 per cent fully adopting, and 2.50 per cent partially adopting them, while 95.83 per cent did not adopt these methods. Predators like red ants, dragonflies, and ladybird beetles also saw minimal adoption, with only 0.83 per cent fully adopting and 0.83 per cent partially adopting them, while the vast majority, constituting 98.34 per cent, did not adopt these predator species. However, the practice of growing pulses or cowpeas on bunds to enhance natural enemy fauna displayed relatively higher adoption rates, with 20.00 per cent fully adopting and 28.33 per cent partially adopting them, although 51.67 per cent did not adopt this method. Adoption of NPV (Nuclear Polyhedrosis Virus) at a rate of 100 LE per acre was not fully adopted by any of the respondents and 0.83 per cent partially adopted it while 99.17 per cent did not adopt this approach. Seed treatment with *Trichoderma viride* or *Trichoderma harzianum* at a rate of 2g per 100g seed exhibited moderate adoption, with 2.50 per cent fully adopting and 3.33 per cent partially adopting it, while 94.17 per cent did not adopt this seed treatment method.

Overall adoption level IPM technology among hybrid tomato growers

Figure 1, provides an overview of the overall adoption levels of Integrated Pest Management (IPM) technology among hybrid tomato growers, categorized into fully adopted, partially adopted, and not adopted. Among the surveyed growers, 1.67 per cent fully adopted IPM technology, indicating a small but notable portion of growers who have fully integrated IPM practices into their tomato cultivation methods. Additionally, 20.00 per cent of growers partially adopted IPM technology, suggesting that a significant portion has incorporated some IPM practices but may not have fully implemented the entire range of strategies. Conversely, the

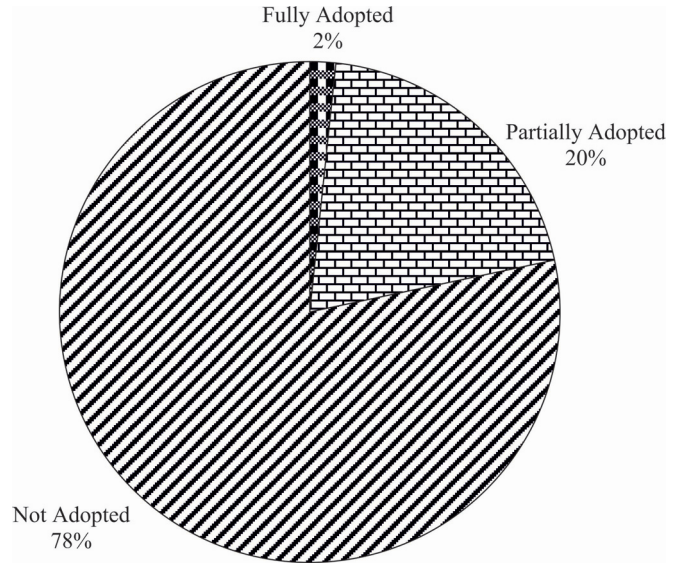


Figure 1. Over-all IPM Adoption Level vis-a-vis Hybrid Tomato

majority of hybrid tomato growers, comprising 78.33 per cent, have not adopted IPM technology at all. This indicates a substantial portion of growers who have yet to embrace or implement IPM practices in their tomato farming operations. Overall, while there is a small segment of growers who have fully embraced IPM, there remains a considerable opportunity for further education, outreach, and support to encourage broader adoption of IPM strategies among hybrid tomato growers.

Multinomial logistic regression between the adoption level of hybrid tomato cultivators and various factors affecting it

The multinomial (polytomous) logistic regression model is an extension of the binomial logistic regression model previously employed by Shukla et al., (2024b) to analyse the factors influencing farmers’ information-seeking behaviour through mobile phones. It ought to be mentioned here at the outset that the multinomial logistic regression model was used for the entire 3 broad categories tested in below Table 2. The criterion level was set to declare a particular respondent in any of the 3 categories viz., Non-adoption, Partial adoption, and Full adoption (Shil et al., 2022). The result of multinomial logistic regression (mlogit model) on determinates of adoption is presented in the below table using ‘Non-adoption’ as the reference category.

Table 2 revealed that Nagelkerke’s R-square or Pseudo R² was 0.609, indicating that 60.90 per cent of the variations in the dependent variable i.e., adoption of IPM practices, were explained by the selected explanatory variables. Table 3 depicted explanatory variables incorporated in the model: Age, year of schooling, family education status, tomato farming experience, social participation,

Table 2. Multinomial logistic regression between the Adoption level of hybrid tomato cultivators and various factors affecting it

	Pseudo R-Square
Cox and Snell	0.462
Nagelkerke	0.609
McFadden	0.435

Table 3. Parameter Estimates of Multinomial Logistic Regression Analysis

Adoption	B	Std. Error	Wald	df	Sig.	Exp(B)	95% CI of Exp(B)	
							Lower Bound	Upper Bound
Intercept	-3.177	6.402	0.246	1	.620			
Age (yr)	-0.202	0.088	5.314	1	.021**	0.817	0.688	0.970
Year of Schooling	0.042	0.157	0.073	1	.787	1.043	0.767	1.420
FES	-0.345	0.532	0.420	1	.517	0.708	0.250	2.009
Tomato farming Experience (yr)	0.063	0.107	0.341	1	.559	1.065	0.863	1.314
Social Participation	-0.116	0.158	0.539	1	.463	0.891	0.654	1.213
Occupation	1.577	0.992	2.527	1	.112	4.839	0.693	33.810
Annual Family Income (Rs)	0.145	0.155	0.872	1	.350	1.156	0.853	1.567
Landholding (ha)	0.527	0.848	0.386	1	.534	1.694	0.321	8.930
Extension Contact	0.604	0.308	3.850	1	.050	1.830	1.001	3.346
Mass media exposure	-0.086	0.159	0.292	1	.589	0.918	0.672	1.253
Cosmopolitness	1.155	0.728	2.519	1	.112	3.174	0.762	13.217
Intercept	11.329	7.583	2.232	1	.135			
Age	-0.312	0.097	10.399	1	.001***	0.732	0.605	0.885
Year of Schooling	0.606	0.265	5.222	1	.022**	1.833	1.090	3.081
FES	-0.401	0.601	0.445	1	.505	0.670	0.206	2.176
Tomato farming Experience	0.139	0.118	1.391	1	.238	1.149	0.912	1.449
Social Participation	-0.333	0.188	3.150	1	.076*	0.716	0.496	1.035
Occupation	1.602	1.042	2.361	1	.124	4.962	0.643	38.280
Annual Family Income	0.136	0.159	0.736	1	.391	1.146	0.839	1.565
Landholding	-0.020	0.954	0.000	1	.984	0.980	0.151	6.359
Extension Contact	0.809	0.325	6.212	1	.013**	2.246	1.189	4.243
Mass media exposure	-0.049	0.190	0.067	1	.0796	0.952	0.656	1.381
Cosmopolitness	1.903	0.874	4.747	1	.029**	6.707	1.211	37.158

The reference category is Non-adoption; Std. Error=SE; 99% CI= 99% Confidence Interval for Exp(B)/Odds ratio (OR); Exp (B)=Exponential of estimate; CI=Confidence Interval; McFadden(.435), Cox and Snell (.462), Nagelkerke .609) Pseudo R-Square values; *significant at 1% level ($P<0.01$); *** Indicates significant at 1% level of significance, in a two-tailed test, ** Indicates significant at 5% level of significance, in a two-tailed test, * Indicates significant at 10% level of significance, in a two-tailed test.

occupation, annual family income, land holding, extension contact, mass media exposure, and cosmopolitness. Among the 11 variables taken to the model only 5 variables viz., Age, year of schooling, social participation, extension contact, and cosmopolitness were found to be significant. Age was statistically significant at 5% level with $p=0.021$, with the fair Wald statistics value of 10.399 vis-à-vis to soar a non-adoption category to fall under partial adoption category and for the significant value decrease at $p<0.01$ ($p=.001$) to move from partial to full adoption category. Years of schooling was significant at 5% with $p=0.022$ to increase from the reference category to the full adoption category. With the fair wald statistics value of 3.150 vis-à-vis to soar from the non-adoption category to the full adoption category. Social participation was statistically positively significant at 10% with $p=0.076$), with the fair wald statistics value of 4.747 vis-à-vis to soar from the non-adoption category to the full adoption category. Social contact was statistically positively significant at 5% with $p=0.013$, with the fair wald statistics value of 6.212 vis-à-vis to soar from the non-adoption category to the full adoption category. Cosmopoliteness was positively significant at a 5% level with $p=0.029$, with the fair Wald statistics value of 4.747 vis-à-vis to soar from the non-adoption category to the full adoption category. The findings were contradictory to the findings of Lal (2017) whereas 'Polychotomous Logistic Regression' for the MH-20 scale divulged

that a unit increase in the 'adoption' variable can increase the odds of immediate attention (the reference category) farmers to become a mentally healthy farmer by 311.50% i.e. (odds ratio [OR], 4.115; 99% CI of OR 1.344 to 12.603) at 5% significance level with Nagelkerke Pseudo R-Square values of 0.744.

DISCUSSION

The results of the study on the adoption levels of IPM practices among hybrid tomato cultivators reveal diverse patterns of adoption influenced by socioeconomic factors and the perceived benefits of each practice. Cultural practices, such as crop rotation and stacking with support sticks, showed relatively higher adoption rates. However, other practices like summer ploughing and the non-burning of LDPE mulch paper were adopted less frequently. The high rate of partial adoption for summer ploughing suggests that while farmers recognize some benefits, there may be barriers to fully integrating these practices, such as labour intensity or insufficient understanding of long-term benefits. In the case of physical and mechanical practices, low adoption rates for critical methods like rouging and flower model traps point to a lack of awareness or accessibility. Conversely, practices like using green nylon nets for white fly control were more widely adopted, indicating that farmers are more likely to adopt visible, effective methods. This suggests the need for more targeted training and demonstrations to increase

the uptake of less familiar but beneficial practices. The adoption of chemical practices also varied, with the majority of farmers fully adopting systemic fungicides for late blight control, showing a preference for familiar chemical solutions. However, low adoption rates of Economic Threshold Levels (ETL) highlight a gap in understanding or trust in this integrated approach, likely due to limited education on its long-term advantages. Meanwhile, biological practices that had particularly low adoption rates among farmers are the use of larval parasites or egg parasitoids. The overwhelmingly high non-adoption rate for larval parasites underscores a significant lack of awareness about the efficacy of biological controls, suggesting an urgent need for educational outreach to promote sustainable, non-chemical pest management solutions.

The study also highlights the influence of socio-economic factors on the adoption of IPM practices. Age was found to be a significant determinant, with older farmers showing greater resistance to adopting new methods, possibly due to established routines or skepticism. On the other hand, higher levels of education were positively correlated with adoption, indicating that schooling plays a crucial role in fostering openness to innovative agricultural practices. Social participation and access to agricultural extension services also had a significant impact on adoption rates, emphasizing the importance of community engagement and extension services in promoting sustainable practices. The Nagelkerke R-square value suggests that these socioeconomic factors account for a substantial proportion of the variability in adoption levels, reinforcing the need for interventions tailored to these variables. These findings have important implications for policymakers and future research. There is a clear need for comprehensive education and outreach programs to promote the adoption of IPM practices among hybrid tomato growers. Policymakers should focus on initiatives that improve access to training on sustainable practices, particularly those with low adoption rates. Promoting community engagement through farmer cooperatives and support networks could also facilitate knowledge sharing and encourage the wider adoption of innovative practices. Future research should focus on developing practical, easy-to-implement guides for farmers and conducting long-term studies on the impacts of adopting IPM practices on crop yields and pest control.

CONCLUSION

The study explores the adoption of IPM practices among hybrid tomato growers in the Kolar district, Karnataka, and the socio-economic factors influencing the adoption. Results indicate varied adoption levels across different IPM categories, with practices like crop rotation showing higher adoption, while biological control methods are less common. Overall, full adoption of IPM is limited, with few growers implementing the practices up to the optimal level. The multinomial logistic regression analysis highlights the significance of certain socio-economic factors such as age, education, social participation, social contact, and cosmopolitanism in influencing adoption levels. These findings underscore the need for targeted interventions and educational programs to promote the adoption of sustainable agricultural practices, particularly among tomato growers. By addressing

barriers to adoption and enhancing awareness about the benefits of IPM, policymakers, and agricultural stakeholders can work towards fostering a more environmentally friendly and economically viable approach to pest management in tomato cultivation.

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Assessment of Farmers' Knowledge towards Sustainable Agricultural Practices (SAP) in Manipur

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HIGHLIGHTS

- Considerable difference of farmers' knowledge level was observed between valley region and hill region in Manipur
- Knowledge index of valley district respondents was higher in comparison to hill district respondents
- Use of Social media information sources highly influenced the knowledge index of respondents in both valley and hill districts

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ABSTRACT

This study explored disparities in farmers' knowledge of sustainable agricultural practices between valley and hilly districts of Manipur, conducted across four districts (Senapati, Churachandpur, Imphal East, and Thoubal) from 2021 to 2023. A total of 320 respondents were selected using a multi-stage random sampling method. The study measured knowledge across six areas: agronomic practices, soil and water conservation, nutrient management, pest control, disease control, and waste recycling. Results revealed that valley districts (Imphal East and Thoubal) had significantly higher knowledge (mean index = 45.07) compared to hilly districts (Senapati and Churachandpur) with a mean index of 30.76. Valley districts excelled in practices like crop rotation and water harvesting, while hilly areas showed lower knowledge, particularly in pest management and water conservation. Information sources such as social media played a critical role, especially in hilly districts. The study highlights the need for region-specific interventions and tailored extension services to address knowledge gaps and promote sustainable farming practices.

INTRODUCTION

Sustainable agriculture is crucial for feeding a growing global population and combating climate change (Mensah, 2019). It helps to protect the environment, preserve natural resources, improve soil fertility and enhance living standard of rural communities (Thangjam et al., 2024). Several factors influencing the adoption of sustainable agricultural practices and most can be contextualised within the adoption paradigms identified by Prager & Posthumus (2010). Liu et al., (2018) and revealed that factors such as information and awareness, farmer's demographics, knowledge and attitudes, characteristics of the farms, characteristics of the sustainable management practices influence the implementation of sustainable management practices. Kumar et al., (2023) highlighted the factors

such as integrated soil fertility management practices, integrated pest management practices, adoption of ZBNF practices, use of live mulching and drip irrigation as significant factors for practicing sustainable agriculture. Knowledge plays a pivotal role in the adoption and successful application of sustainable agricultural methods. When individuals are exposed to innovations, they seek to understand how these methods function, initiating the learning process. Cognitive factors relate to the adoption of sustainable practices because the adoption of specific sustainable agricultural practices has been observed higher when farmers have sufficient knowledge (Thangjam & Jha 2024). In rural communities, especially in developing regions, the extent of farmers' knowledge about modern agricultural techniques, sustainable practices, and resource

management often determines the productivity and long-term viability of farming systems. According to Karangami et al., (2019) & Gebaska et al., (2020) farmers' knowledge significantly influences their ability to adopt innovations that improve both the efficiency and sustainability of agricultural practices. The shaping of farmers' knowledge is a complex and multi-stranded process which, in part, is closely linked to place according to Wojcik et al., (2019). Knowledge gained through learning or direct experience, making it crucial for the effective adoption of sustainable agricultural methods (Thomas et al., 2020). Local farmers' knowledge of sustainable agriculture represents a vast body of practical experience and the capacity for knowledge generation, both of which are crucial for achieving sustainability and development goals. Therefore, it is essential to understand the depth of farmers' knowledge regarding sustainable agricultural practices (Ghosh et al., 2020). While sustainable agriculture is inherently knowledge-intensive, many farmers, particularly in regions like Manipur, still lack the necessary understanding and skills for its effective implementation. Few studies have explored the importance of farmers' knowledge of sustainable practices, and even fewer have examined how socio-economic factors influence this knowledge in the state. Understanding these factors is critical to ensuring the successful adoption of sustainable agricultural practices (SAP) and their potential to improve farmers' livelihoods while promoting environmentally friendly production systems. This research aims to assess the knowledge levels of farmers across different districts in Manipur, using a comprehensive knowledge index to evaluate their understanding of sustainable agricultural practices.

METHODOLOGY

The present study was conducted in Manipur across four districts during 2021-23. A multi-stage random sampling method was employed in four districts; Senapati and Churachandpur districts represent the hill region while Imphal East and Thoubal districts represent the valley region having the highest cultivated area and highest crop productivity in the state. From each district, two blocks were randomly selected, arriving a total of eight blocks being selected randomly. Furthermore, two villages were selected from each block, 20 respondents were selected from each village randomly, arriving a total sample of 320 respondents. This sampling design ensured a comprehensive representation of the target population in hill and valley region of the state. Prior to this present study, a pilot study was conducted in hill district and valley districts of the state through direct interview and field visit methods. Following the pilot study, various sustainable agricultural practices were identified and lists of sustainable agricultural practices (SAP) were prepared. Among the identified SAPs, six dimensions viz., agronomic practices, soil and water conservation, nutrient management, pest control methods, diseases control methods and recycle management were selected based on the most concerned sustainable practices in agriculture engaged by the farmers of the state.

The knowledge indexes (KI) of the respondents were measured by conducting a face to face interaction and direct interview method with the help of the interview schedule consisting close ended questions. Respondent's response was recorded and the analysis

included binary scores with the answer "yes" coded as 1, while the answer "no" coded as 0 for each question which were added together to get a knowledge score for developing knowledge index. 't' value was also calculated to know the significant difference of knowledge level of farmers on sustainable agricultural practices between hill districts and valley districts. The six dimensions were also ranked separately for valley districts and hill districts based on the mean score of knowledge level to illustrate the knowledge gap among the dimension of SAP across the districts. Regression analysis was carried out to identify and quantify the relationships between socio economic factors and knowledge level of the farmers.

RESULTS

Table 1 presents the knowledge index for sustainability practices across four districts: Thoubal, Imphal East, Senapati, and Churachandpur. The analysis reveals notable differences in farmers' knowledge of sustainable farming practices, with farmers of Thoubal and Imphal East generally exhibiting higher knowledge levels compared to farmers of Senapati and Churachandpur. In agronomic practices, farmers of Thoubal led in knowledge of improved varieties (56.25%), followed by farmers of Imphal East (52.50%). Farmers of Senapati (35.00%) and Churachandpur (30.00%) showed lower knowledge levels. For the sustainable practice crop rotation, farmers of Thoubal (75.00%) had the highest knowledge index followed by Imphal East (70.00%), while farmers of both Senapati and Churachandpur districts had moderate knowledge (62.50%). For inter-cropping, farmers of Churachandpur (70.00%) had the highest knowledge, followed by farmers of Imphal East (50.00%) and Senapati (47.50%), whereas farmers of Thoubal had the lowest (43.75%) knowledge.

In soil and water conservation, farmers of Thoubal (40.00%) and Imphal East (37.50%) had below-moderate knowledge of conservation tillage, with farmers of Senapati (22.50%) and Churachandpur (37.50%) showing even lower levels. For pond water harvesting, farmers of Thoubal (57.50%) had the highest knowledge, followed by farmers of Imphal East (51.25%), while farmers of Senapati (23.75%) and Churachandpur (11.25%) had significantly lower knowledge. In mulching, farmers of Imphal East (50.00%) had the highest knowledge, followed by farmers of Thoubal (42.50%), with farmers of Senapati (30.00%) and Churachandpur (33.75%) districts showing below-moderate knowledge. In nutrient management, farmer's knowledge of cover crops was low across all districts- with Imphal East (38.75%), Senapati (40.00%), Thoubal (37.50%), and Churachandpur (28.75%). In green manure, farmers of Imphal East (37.50%) had the highest knowledge, followed by farmers of Thoubal (33.75%), but both Senapati (23.75%) and Churachandpur (20.00%) districts' farmers had very low levels of knowledge. For organic fertilizers, farmers of Thoubal (47.50%) had the highest knowledge, followed by farmers of Imphal East (43.75%), while farmers of Churachandpur (41.25%) and Senapati (31.25%) had lower levels. Regarding pest control, farmers of Imphal East (48.75%) had the highest knowledge, followed by farmers of Thoubal (40.00%), with farmers of Churachandpur (21.25%) and Senapati (13.75%) showing very low knowledge. In biological control, farmers of Imphal East (41.25%) led, though still below-moderate, while farmers of Thoubal

Table 1. Knowledge level of sustainable agricultural practices (SAP) in sampled districts

Dimensions of SAP	Sustainable practices	Knowledge index (KI)		KI of valley districts (n=160)	Knowledge index (KI)		KI of hill districts (n=160)
		THB (n=80)	IME (n=80)		SNP (n=80)	CCP (n=80)	
Agronomic practice	Improved variety	56.25	52.50	54.38	35.00	30.00	32.50
	Crop rotation	75.00	70.00	72.50	62.50	62.50	62.50
	Inter-cropping	43.75	50.00	46.88	47.50	70.00	58.75
Soil and water conservation	Conservation tillage	40.00	37.50	38.75	22.50	37.50	30.00
	Pond water harvesting	57.50	51.25	54.38	23.75	11.25	17.50
	Mulching	42.50	50.00	46.25	30.00	33.75	31.88
Nutrient Management	Plantation of cover crop	37.50	38.75	38.13	40.00	28.75	34.38
	Green manure	33.75	37.50	35.63	23.75	20.00	21.88
	Organic fertilizer	47.50	43.75	45.63	31.25	41.25	36.25
Pest control method	Physical control	40.00	48.75	44.38	13.75	21.25	17.50
	Biological control	23.75	41.25	32.50	6.25	10.00	8.13
	Cultural control	30.00	15.00	22.50	18.75	22.50	20.63
Diseases control method	Physical control	43.75	37.50	40.63	28.75	36.25	32.50
	Biological control	36.25	46.25	41.25	6.25	12.50	9.38
	Cultural control	30.00	35.00	32.50	16.25	18.75	17.50
Recycle management	Field waste	78.75	76.25	77.50	41.25	37.50	39.38
	Animal waste	36.25	18.75	27.50	35.00	30.00	32.50
	Plant waste	62.50	57.50	60.00	61.25	40.00	50.63

(23.75%), Churachandpur (10.00%), and Senapati (6.25%) had very low knowledge levels. For cultural control, farmers of Thoubal (30.00%) and Churachandpur (22.50%) exhibited higher knowledge compared to Imphal East (15.00%) and Senapati (18.75%), thus, farmers of all districts had below-moderate knowledge. In disease control methods, knowledge of farmers regarding physical control was relatively higher in Thoubal (43.75%) and Imphal East (37.50%), with Senapati (28.75%) and Churachandpur (36.25%) showing lower levels. For biological control, farmers of Imphal East (46.25%) had the highest knowledge, followed by Thoubal (36.25%), while farmers of Senapati (6.25%) and Churachandpur (12.50%) had very low levels. In cultural control, farmers of Imphal East (35.00%) had the highest knowledge, though still below-moderate, followed by farmers of Thoubal (30.00%), Churachandpur (18.75%), and Senapati (16.25%) districts. In recycle management, farmers of Thoubal (78.75%) and Imphal East (76.25%) demonstrated high knowledge of field waste management, while farmers in Senapati (41.25%) and Churachandpur (37.50%) had lower knowledge levels. For animal waste management, farmers of Thoubal (36.25%) and Senapati (35.00%) had below-moderate knowledge, while farmers of Imphal East (18.75%) and Churachandpur (30.00%) had very low knowledge. In plant waste recycling, farmers of Thoubal (62.50%) and Senapati (61.25%) showed strong knowledge, followed by Imphal East (57.50%), while farmers of Churachandpur (40.00%) exhibited lower knowledge. Overall, farmers of Thoubal and Imphal East districts demonstrated

higher knowledge levels. In contrast, farmers of Senapati and Churachandpur had relatively lower knowledge levels in areas such as water harvesting, pest control, and nutrient management.

Table 2 revealed that the mean farmer's knowledge index was higher for the valley district (45.07) compared to the hill district (30.76), indicating that farmers in the valley district have greater knowledge of sustainable agricultural practices. The t-values (29.973 for the valley district and 24.842 for the hill district) suggest a significant difference between the two groups' knowledge indices. Overall, it is indicated that the difference in the knowledge level of the farmers have resulted significant variation in adopting the SAP dimensions in selected districts with the valley district farmers exhibiting a higher level of knowledge. The data pertaining to ranking of different dimensions affecting the sustainable agricultural practices (SAP) revealed that distinct differences in performance across various dimensions in valley and hill districts (Table 3). Comparatively, valley districts generally outperformed hill districts in most dimensions of SAP, with higher mean scores and knowledge index (KI) percentages. Among the different dimensions, agronomic practice was the top-ranked dimension in both districts, with valley districts achieving a mean (1.74) and KI (57.92%), while hill districts scored slightly lower with a mean (1.53) and KI (51.25%).

In terms of soil and water conservation, valley districts showed significantly stronger performance, scoring a mean (1.39) and KI (46.46%), ranking III, compared to hill districts, which scored much lower with a mean (0.79) and KI 26.46%, ranking IV. Similarly, for

Table 2. Comparative knowledge of farmers between valley and hill districts on the sustainable agricultural practices (SAP)

Districts	Mean	Std. Deviation	Knowledge index	t value	P value
Valley district	13.812	4.122	45.07	29.973	0.001
Hill district	9.625	3.465	30.76	24.842	0.001

Table 3. Ranking of the dimension of sustainable agricultural practices (SAP) based on the mean knowledge level of the respondents

S.No.	Dimensions of SAP	Valley districts			Hill districts		
		Mean	KI %	Ranking	Mean	KI %	Ranking
1.	Agronomic practice	1.74	57.92	I	1.53	51.25	I
2.	Soil and water conservation	1.39	46.46	III	0.79	26.46	IV
3.	Nutrient Management	1.19	39.80	IV	0.92	30.84	III
4.	Pest control method	0.99	33.13	VI	0.46	15.42	VI
5.	Diseases control method	1.44	38.13	V	0.59	19.79	V
6.	Recycle management	1.65	55.00	II	1.22	40.84	II

Maximum mean value = 3 and Minimum mean value = 0

Table 4. Socio-economic determinants of farmers' knowledge on sustainable agricultural practices (SAP)

Model	Valley districts				Hill districts			
	Unstandardized Coefficients		t	p	Unstandardized Coefficients		t	p
	B	Std. Error			B	Std. Error		
Constant	1.016	1.742	.583	.561	.800	2.351	.340	.734
Age (X_1)	.064	.031	2.029	.044*	.002	.039	.060	.952
Education (X_2)	-.036	.065	-.553	.581	.065	.067	.972	.333
Family size (X_3)	-.040	.143	-.278	.781	-.066	.773	-.086	.932
Family type (X_4)	.140	.465	.302	.763	.598	.247	2.422	.014*
Experience in agriculture (X_5)	.134	.039	3.408	.001**	-.015	.038	-.408	.684
Total land holding (X_6)	.053	.221	.240	.810	-1.031	.000	-1.287	.200
Annual income (X_7)	-7.006	.000	-7.718	.474	.600	.301	2.107	.037*
Extension contact (X_8)	.179	.165	1.086	.279	.099	.197	.504	.615
Informal information sources (X_9)	.557	.125	4.449	.000**	-.042	.177	-.239	.811
Mass media information sources (X_{10})	.282	.148	1.908	.058	.216	.184	1.176	.242
Social media information sources (X_{11})	.709	.149	4.744	.000**	.323	.166	2.664	.009**
Market orientation (X_{12})	.133	.061	2.177	.031*	-.013	.054	-.243	.808

Valley districts: R Square = 0.644; Adjusted R square = 0.572; F value = 5.628; P value = 0.01

Hill districts: R Square = 0.532; Adjusted R square = 0.457; F value = 2.071; P value = .019

nutrient management, valley districts registered a mean (1.19) and KI (39.80%), ranked IV, while hill districts ranked III with a mean (0.92) and KI (30.84%). Though both districts showed progress, valley districts demonstrated more effective nutrient management practices. In pest control methods, valley districts scored a mean (0.99) and KI (33.13%), ranking VI, while hill districts showed lower mean (0.46) and KI (15.42%), also ranking VI. Similarly, in disease control, valley districts had higher mean (1.44) and KI (38.13%), ranked V, while hill districts scored lower, mean (0.59) and KI (19.79%), also ranking V. While both districts ranked similarly, valley districts showed a much stronger approach to disease control. Finally, in recycle management, both districts performed well, with valley districts achieving a mean (1.65) and a KI (55.00%), ranked II, and hill districts scoring a mean (1.22) and KI (40.84%), also ranked II. Despite the same ranking, the valley districts demonstrated a higher level of recycling practices and knowledge.

From Table 4 it was found that in case of the valley districts, the variables, Age ($t = 2.029$, $p = 0.044$), experience in agriculture ($t = 3.408$, $p = 0.001$), informal information sources ($t = 4.449$, $p = 0.000$), Social media information sources ($t = 4.744$, $p = 0.000$) and market orientation ($t = 2.177$, $p = 0.031$) had a significant relationship with the knowledge of farmers on SAP. Further R-squared value of 0.644 for the valley districts indicating 64.4% of

the variability in farmers' knowledge of sustainable farming systems is represented by independent variable used in the model. In contrast, in case of the hill districts, the variables Family type ($t = 2.422$, $p = 0.014$), annual income ($t = 2.107$, $p = 0.037$) and social media information sources ($t = 2.664$, $p = 0.009$) had a significant relationship with the knowledge of farmers on SAP. The model for the hilly area has a lower explanatory power, with an R-squared value of 0.532, which accounted for 53.2% of the variability in farmers' knowledge of sustainable farming systems.

DISCUSSION

The findings of this study underscore the significant disparities of farmers of valley and hill districts on the knowledge of sustainable agricultural practices as well as socio-economic factors, highlighting key areas for targeted intervention and capacity building. In the study it was evident that farmers in the valley districts (Thoubal and Imphal East) exhibited a higher overall knowledge of sustainable farming practices compared to their counterparts in the hilly districts (Senapati & Churachandpur). Liao et al., (2022) reported that over half of the farmers had good levels of knowledge on sustainable agriculture.

The valley districts acquired better knowledge of SAP, such as crop rotation, water harvesting, and recycle management. These findings are consistent with the assumption that valley areas may

have better access to resources, extension services, and infrastructure, all of which can enhance farmers' understanding that help to increase the knowledge of SAP. In contrast, the hilly district, with more challenging terrain and limited access to modern farming technologies and information channels, displayed lower knowledge levels among farmers in several SAP, particularly water harvesting, pest control method, and nutrient management. This disparity in knowledge levels between valley and hilly districts emphasizes the need for context-specific interventions that account for the unique challenges faced by farmers in hilly regions. Farmers have lower knowledge level in diseases and pest management as compared with other practices such as agronomic practices, soil management practice, and nutrient and recycle management. Our findings were consistent with the previous studies of Sarma et al., (2022); Podikunju & Arathy (2022); Pawar & Channaveer (2021) where it was found that majority of the farmers were unaware or lack of knowledge on pest and disease control. However, findings of Kumar & Jahanara (2021) emphasized that farmer's knowledge related to disease and pest control increases due to impart trainings and other capacity building programmes. The role of information sources had significant impact in both valley and hilly areas. In this context, Swami, (2022) found that there was significant association of information seeking behaviour of the farmers with their knowledge level.

In the valley districts, informal information sources, mass media information sources and social media emerged as key facilitators of knowledge about SAP, reinforcing the importance of non-traditional information channels. Farmers in the valley districts were more likely to rely on informal information sources in disseminating SAP. In contrast, in the hilly districts, social media also had a significant positive effect on knowledge of farmers, but other information sources, like mass media, have not produced a significant impact on farmer knowledge. Overall, it is suggested that social media platforms might serve as critical tools for bridging knowledge gaps in hill regions where access to formal education and extension services is limited. Socio-economic factors have influenced on farmer's knowledge, though the patterns differed between the valley and hilly district were observed. Age of the farmers was an important explanatory variable in line with the findings of Kumar et al., (2020); Musafifiri et al., (2020) & Serebrennikov et al., (2020). In the valley districts variables viz., age, experience in agriculture, and market orientation were positively associated with higher knowledge levels of sustainable farming systems. Older farmers with more years of experience in agriculture might have developed a deeper understanding of traditional farming practices and were likely better positioned to integrate these with newer sustainable methods. Asmara et al., (2023) stated that farmer's knowledge increased considering their long experience of farming which eventually helps farmers in achieving high income and increase knowledge on sustainable agriculture.

Additionally, education and extension contact were found insignificant it might be due to respondents were not contacted with the extension agent and this finding is contrast with the results of Mishra et al., (2024) where education, extension participation, were positively and significantly related to the knowledge index of farmers. Moreover, farmers with stronger market orientation may be more attuned to the economic benefits of adopting sustainable

practices, such as increased yield, cost reduction, and market demand for eco-friendly products. Interestingly, family size and land holding area did not produced significant impact on knowledge levels in the valley, suggesting that other factors, such as access to information and community support, play a more critical role. In hill districts variables, family type, annual income, and social media usage had a significant and positive association with knowledge. It is possible that farmers in larger or more diversified family set-ups might have greater collective knowledge, with multiple family members contributing to the farming process.

Similarly, higher annual income could enable farmers to invest more in sustainable technologies, training, or information sources that improve their knowledge. However, experience in agriculture, age, and extension contacts did not significantly affect knowledge levels in the hilly regions, which could be due to the limited presence and effectiveness of formal extension services in these more remote areas. The lack of impact of extension contact in the hilly areas further underscores the need for innovative and locally adapted extension models that better cater to the specific needs of these regions. The lower explanatory power of the model for the hilly areas (R Sq: 0.532) compared to the valley areas (R Sq: 0.644) suggests that other unaccounted factors may influence knowledge in the hilly regions. These could include environmental conditions, access to markets, and local cultural practices, which may not be fully captured by the socio-economic variables examined in this study. The lower R-square value in the hilly areas also points to the need for a more understanding of the local context and potentially the incorporation of additional variables, such as environmental constraints and farming practices that could better explain knowledge variations in these regions.

Overall, the study highlights the need for tailored educational programs and extension services that consider the specific socio-economic and environmental contexts of different regions. In valley areas, where knowledge levels are higher, efforts could focus on reinforcing the use of modern technologies and practices, as well as improving market access. In contrast, hilly areas, where knowledge levels were lower, could benefit from targeted interventions that emphasize water conservation techniques, pest management, and nutrient management, along with enhanced access to information through social media and informal networks. Creating awareness programme on sustainable agricultural practices may increase the farmer's knowledge. Gebaska et al., (2020) reported that awareness programme resulted in higher knowledge and better implementation of sustainable practices among farmers. Additionally, integrating sustainable farming practices in the state agricultural policies and developing stronger linkages between formal extension services and local community networks could help bridge knowledge gaps in sustainable farming practices across both valley and hilly areas of Manipur.

CONCLUSION

The farmers in the valley districts generally possess higher levels of knowledge compared to their counterparts in the hilly districts. In valley districts, informal information networks, mass media, and social media were pivotal in disseminating knowledge on sustainable practices, whereas in hilly districts, social media

played a particularly important role in bridging knowledge gaps. Variables such as age, experience, informal and social media information sources as well as market orientation positively influenced the knowledge levels of farmers in valley areas, while family type, income, and social media usage emerged as key drivers in the hilly areas. Targeted interventions are needed, particularly in hill areas such as water conservation, pest management, and nutrient management, alongside enhancing information access through social media and informal networks. Creating awareness programs and integrating sustainable farming practices into agricultural policies will be crucial in bridging knowledge gaps and promoting the sustainable agricultural practices across Manipur.

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Effectiveness of NGO-Led Livelihood Initiatives on Income Generation among Rural Women of Bihar

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HIGHLIGHTS

- Across all NGO-Led livelihood initiatives, rural women experienced substantial savings growth.
- Tailoring emerged as the most popular and profitable livelihood activity, and their average income increasing from Rs 7,600 to Rs 16,000.
- Despite lower engagement compared to other activities, papad making demonstrated a remarkable income surge from Rs 5,777 to Rs 17,975.
- Mean earnings in agriculture rose from Rs 54,741.83 to Rs 76,733.54, with a highly significant t-statistic, underscoring their pivotal role in rural economic upliftment.

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ABSTRACT

The study explored the effectiveness of NGO-Led livelihood initiatives on income generation among rural women of Bihar. 450 rural women from 3 districts of Bihar were selected and data was collected during the year 2023-24. This study adopted a descriptive approach, using structured close-ended questionnaires through quantitative analysis involving interviews and surveys to collect information. Key activities such as tailoring, farming, handicrafts, homestead farming, and animal husbandry saw high engagement rates, with tailoring being the most popular at 97.33%. These initiatives significantly improved household financial stability, as evidenced by increased income, expenditure, and savings across all sectors. Tailoring, for instance, boosted average income from Rs 7,600 to Rs 16,000, while savings more than doubled. Similarly, papad-making, handicrafts, and animal husbandry demonstrated substantial profitability and improved resource management. Farming recorded the highest income increase, with a mean rise from Rs 54,742.83 to Rs 76,733.54, supported by a highly significant t-statistic of 13.91. Overall, the findings underscore the success of NGO-Led livelihood initiatives in promoting sustainable livelihoods and financial resilience among rural women in Bihar.

INTRODUCTION

Livelihood development plays a pivotal role in rural transformation, particularly for women in regions where traditional economic structures have often marginalized them. In rural Bihar, where agriculture remains the primary occupation, the lack of diversified income-generating opportunities has posed significant

socio-economic challenges for women. Income from animal husbandry, marginal works and labouring, were positively correlated with diversity; but land holding, income from agriculture, possession of household assets, average family education and maximum family education are negatively correlated with diversity (Pal et al., 2017). Over the years, non-governmental organizations (NGOs) have emerged as critical agents of change, introducing livelihood initiatives

aimed at fostering economic empowerment and social inclusion for rural women. These initiatives encompass a broad spectrum of activities, including vocational training, self-help group (SHG) formation, microfinance, handicrafts, and agri-based enterprises. Such interventions have not only provided women with alternative income sources but also enhanced their decision-making capabilities, social status, and overall quality of life. The significance of NGO-led livelihood initiatives lies in their ability to address the multi-dimensional barriers faced by rural women. Traditional gender roles, limited access to education, inadequate financial resources, and societal norms have historically restricted women's economic participation in Bihar. NGOs, through tailored programs, aim to bridge this gap by providing skill development, credit access, market linkages, and capacity-building opportunities. By fostering entrepreneurship and self-reliance, these livelihood initiatives help rural women transition from subsistence living to active contributors in their local economies. NGOs have been recognized globally for their role in fostering women's economic empowerment through livelihood initiatives. In his study, Kabeer (1999) demonstrated that economic empowerment involves not only income generation but also access to resources, decision-making power, and the ability to control one's life outcomes. NGOs have been instrumental in providing these opportunities by facilitating vocational training, microfinance, and self-employment ventures. Various studies highlight the success of NGO-led livelihood initiatives in rural India. A study by Kumar & Singh (2022) reported that NGO interventions in Bihar have significantly increased household income, particularly through skill enhancement and market linkages. The study revealed that women involved in tailoring and dairy farming experienced a 45 per cent increase in their average monthly income. In Bihar, NGOs have introduced programs focusing on tailoring, handicrafts, and agri-based businesses. Sinha & Sinha (2012) found in his study that such initiatives not only increase household income but also improve women's social standing within their communities. Singh et al., (2015) found that skill development programs in Bihar have equipped women with marketable skills, (weaving, tailoring, and food processing) leading to enhanced employability and entrepreneurship. Kumar & Sharma (2017) highlighted the need for continuous training and market linkages to sustain these income-generating activities. Without access to broader markets, many initiatives fail to achieve long-term financial stability for participants. Several region-specific studies have examined the impact of NGO interventions in Bihar. Sharma & Devi (2021) revealed that women participating in NGO-led initiatives experienced a 30 per cent increase in household income over five years. Additionally, Prakash et al., (2022) noted improvements in women's financial literacy and community engagement as a result of targeted training programs.

METHODOLOGY

The present study was conducted in Bihar, adopting a descriptive research approach to analyse the effectiveness of NGO-led livelihood initiatives such as tailoring, papad making, handicrafts and artisanal work, homestead farming of vegetables/kitchen gardening, animal husbandry and dairy farming, and farming on

income generation among rural women. The data collection was undertaken in three districts i.e., Muzaffarpur, Samastipur, and Patna, using a purposive stratified random sampling technique. Five NGOs were randomly selected from each district. From each NGO, 30 rural women were randomly chosen, resulting in a total sample size of 450 respondents. The selected NGOs from Muzaffarpur included Hanuman Prasad Gramin Vikas Seva Samiti, Akhil Gramin Yuva Vikas Samiti, Kanchan Seva Ashram, Akansha Seva Sadan, and Nirdesh. In Samastipur, the selected NGOs were Anmol Uphaar Seva Foundation, Bhatri Lok Kalyan Seva Ashram, Mithilaanchal Vikas Samiti, Asha Seva Sansthan, and Gramin Samaaj Kalyan Sanstha. From Patna, the NGOs included Didi Jee Foundation, Ram Janki Pragati Seva Sansthan, Aga Khan Foundation, Prayas Bharti Trust, and Nari Gunjan. Data was collected through a self-structured, close-ended questionnaire. The structured survey focused on eliciting information related to the study's objectives. Statistical tools and techniques, including frequency and percentage analysis, were employed to interpret the results. To compare mean income levels before and after rural women joined the NGOs, the paired t-test was used at a 5% level of significance with (n-1) degrees of freedom. The findings were processed and presented in tabular form for clarity. The formula for the paired t-test is:

$$t = \frac{d}{\frac{S_d}{\sqrt{n}}}$$

Where; d: Mean of the differences in income, S_d : Standard deviation of the differences, n: Number of paired observations

RESULTS

Engagement of rural women in NGO-Led livelihood initiatives

The analysis of Table 1 reveals the engagement by rural women in various NGO-led livelihood initiatives aimed at income generation. Tailoring emerged as the most popular activity, with 97.33 per cent of rural women engaged in this sector, indicating its significant role in providing sustainable income opportunities. Similarly, farming-related initiatives also saw strong participation, with 94.44 per cent of rural women involved, highlighting the importance of agricultural activities in their livelihoods. Handicrafts and artisanal work demonstrated a substantial engagement rate of 93.33 per cent, reflecting the growing appeal of traditional skills in generating income. This was closely followed by homestead farming and kitchen gardening, with 89.55 per cent engagement, showcasing how small-scale agricultural practices are being adopted for both subsistence and income generation. Animal husbandry and dairy farming also garnered notable involvement, with 87.77 per cent of rural women engaged, emphasizing the value of livestock-based livelihoods in rural economies. Lastly, papad making, though slightly lower in engagement compared to other activities, still recorded a significant engagement rate of 83.33 per cent, illustrating its potential as a supplementary income source for rural households.

Overall, these figures indicate that NGO-led initiatives are highly effective in mobilizing rural women across diverse livelihood sectors, contributing to their economic empowerment and enhancing their household income stability.

Table 1. Engagement of rural women in NGO-Led livelihood income generation initiatives

NGO-Led livelihood initiatives	Engagement (%) (n = 450)
Tailoring	438 (97.33%)
Papad making	375 (83.33%)
Handicrafts and Artisanal Work	420 (93.33%)
Homestead farming of vegetables/ kitchen gardening	403 (89.55%)
Animal Husbandry and Dairy Farming	395 (87.77%)
Farming	425 (94.44%)

Effectiveness of NGO-Led Livelihood Initiatives on Income, Expenditure, and Savings of rural women

The findings of Table 2 highlights the effectiveness of NGO-Led Livelihood Initiatives on Income, Expenditure, and Savings of rural women by comparing their income, expenditure, and savings before and after engaging in various livelihood initiatives. Women engaged in tailoring experienced a significant rise in their average income from Rs 7,600 to Rs 16,000. This increase was driven by enhanced skills and better market access provided through NGO

Table 2. Income, Expenditure, and Savings of rural women in different initiatives

NGO-Led Livelihood initiatives	Economic development	Before joining	After joining
Tailoring	Income	7600	16000
	Expenditure	3000	5000
	Savings	4600	11000
Papad making	Income	5777	17975
	Expenditure	2300	5500
	Savings	3477	12475
Handicrafts & Artisanal Work	Income	10980	20000
	Expenditure	6600	8600
	Savings	4380	11400
Homestead farming of vegetables/kitchen gardening	Income	9500	11800
	Expenditure	3200	4100
	Savings	6300	7700
Animal Husbandry & Dairy Farming	Income	12800	15875
	Expenditure	5000	6200
	Savings	7800	9695
Farming	Income	13680	15500
	Expenditure	6200	7200
	Savings	7480	8300

training programs. Despite a rise in expenditure from Rs 3,000 to Rs 5,000, their savings more than doubled, growing from Rs 4,600 to Rs 11,000, indicating effective financial management training and profitability. Participants in papad-making saw their income increase dramatically from Rs 5,777 to Rs 17,975. This was facilitated by scaling operations and improved production efficiency. Although expenditures rose from Rs 2,300 to Rs 5,500 due to higher production costs, savings surged from Rs 3,477 to Rs 12,475, reflecting better resource utilization and profitability from expanded market linkages. In the handicrafts and artisanal work, income rose from Rs 10,980 to Rs 20,000, and savings increased from Rs 4,380 to Rs 11,400, despite expenditures rising from Rs 6,600 to Rs 8,600. The growth is attributed to enhanced craftsmanship skills, improved product quality, and access to wider markets supported by NGO efforts. For homestead farming of vegetables/kitchen gardening, income grew from Rs 9,500 to Rs 11,800, with savings increasing from Rs 6,300 to Rs 7,700, driven by the introduction of sustainable practices and efficient resource allocation. Similarly, participants involved in animal husbandry and dairy farming reported income growth from Rs 12,800 to Rs 15,875, with savings increasing from Rs 7,800 to Rs 9,695. This improvement resulted from cost management, access to better tools, and productivity gains facilitated by NGO training. In farming, income increased modestly from Rs 13,680 to Rs 15,500, and savings rose from Rs 7,480 to Rs 8,300. This growth was supported by the adoption of innovative farming methods and resource efficiency introduced by NGOs.

Across all initiatives, rural women achieved higher incomes and savings, with only a proportionate increase in expenditure. These initiatives have empowered rural women economically, helping them manage their expenses better and increase their savings, which can contribute to long-term financial stability and independence.

Effectiveness of NGO-Led livelihood initiatives on income generation among rural women

The findings in Table 3 highlights the effectiveness of NGO-Led livelihood initiatives on income generation among rural women. Farming shows the highest increase in income, with mean earnings rising from Rs 54,741.83 to Rs 76,733.54, supported by a t-statistic of 13.91, indicating a highly significant impact. Tailoring also reflects substantial income growth, with average incomes increasing from Rs 14,423 to Rs 25,530, and a t-statistic of 7.02, emphasizing their effectiveness. Handicrafts and artisanal work exhibit a remarkable improvement in earnings, increasing from Rs 10,600 to Rs 21,456, supported by a t-statistic of 6.87. Similarly, homestead farming, including vegetable and kitchen gardening, shows a notable rise from Rs 14,890.84 to Rs 22,765.95, with a t-statistic of 4.98,

Table 3. Effectiveness of NGO-Led livelihood initiatives on income generation among rural women

NGO-Led livelihood initiatives	Mean Income		t-statistics
	Before joining	After joining	
Tailoring	14423	25530	7.02**
Handicrafts and Artisanal Work	10600	21456	6.87**
Homestead farming of vegetables/kitchen gardening	14890.84	22765.95	4.98**
Animal Husbandry and Dairy Farming	28654	40984	7.79**
Farming	54741.83	76733.54	13.91**

**Significant at 5%

indicating a significant impact. Animal husbandry and dairy farming initiatives have also contributed significantly, with income increasing from Rs 28,654 to Rs 40,984, and a strong t-statistic of 7.79.

Overall, all initiatives show statistically significant improvements in income at the 5% level, highlighting the effectiveness of NGO-Led livelihood initiatives in enhancing the economic well-being of rural women across various livelihood initiatives.

DISCUSSION

The findings reveal a significant positive impact on the income, expenditure, and savings of rural women in Bihar, demonstrating the effectiveness of these livelihood initiatives in enhancing their economic well-being. The high engagement rates in various livelihood initiatives like tailoring, farming, handicrafts, and animal husbandry underscore the relevance of these initiatives in the rural economy. Non-Governmental agencies are playing proactive role in mobilizing, organizing and strengthening SHGs. Necessary managerial, technical mobilizing, organizing and strengthening SHGs. Necessary managerial, technical and marketing skills are being imparted to groups to enhance their livelihood opportunities. SHGs specifically women oriented had made a positive attempt towards women socioeconomic transformation and upliftment to make them torch bearer of the society (Slathia et al., 2006). Choudhary (2019) found from his study that NGOs played a crucial role in diversifying rural women's income sources in Bihar by introducing non-farm activities like tailoring, papad-making, and vegetable vending.

The study showed that women involved in multiple livelihood activities earned up to 60 per cent more than those relying solely on agriculture. This diversification also reduced their vulnerability to seasonal income fluctuations. Tailoring and agriculture emerged as the most popular, engaging over 90 per cent of rural women, which is consistent with earlier studies that highlight these sectors as primary sources of income for rural women in India (Sharma & Devi, 2021). Studies indicate that sectors such as tailoring and agriculture offer scalable and sustainable livelihood opportunities for rural women, as they rely on locally available resources and cater to both local and external markets (Reddy & Manak, 2005). Sharma (2021) highlights that skill development programs initiated by NGOs have empowered rural women economically and socially. In Bihar, tailoring and handicrafts emerged as primary sources of income. The training provided by NGOs not only enhanced technical skills but also improved financial literacy, leading to better income management and increased savings.

This finding suggests that when NGOs tailor interventions to fit local needs and market demands, participation rates increase significantly, as women recognize the potential for financial independence and community development. The significant increase in income, coupled with higher savings, aligns with the findings of Patel (2020), who highlighted the positive economic outcomes of NGO-led interventions through microcredit and skills training. For example, tailoring initiatives more than doubled the savings of participants, and similar trends were observed in other activities like papad-making and handicrafts. This supports the argument that income-generating activities facilitated by NGOs not only increase household income but also improve women's financial autonomy,

a core component of empowerment (Tripathi & Jain, 2018). Kabeer (1999) conducted a study and argues that increased income typically results in higher expenditures, especially when the enterprise expands, as women invest in materials, tools, and training to improve production quality and quantity. Singh et al., (2015) points out in his study that when women are given access to financial services and training, they tend to manage resources more effectively, leading to increased savings and better financial planning. This is a crucial outcome, as savings provide rural women with a buffer against economic shocks and increase their bargaining power within households and communities.

The findings show that agriculture-based initiatives, along with tailoring and animal husbandry, had the most significant impact on income generation. Jha et al., (2020) conducted a study and examined the role of NGOs in supporting agricultural practices such as homestead farming, vegetable gardening, and animal husbandry. Their research indicated a 35 per cent rise in household income among women engaged in these activities, with NGOs providing critical inputs like seeds, livestock, and technical training. The study concluded that these interventions significantly contributed to rural economic stability. The agricultural sector's growth, where average incomes rose by over Rs 20,000, is in line with Sinha & Sinha (2012), who argued that agriculture, when integrated with modern practices and supported by NGOs, can substantially improve rural women's economic outcomes. This is particularly true when NGOs provide technical support, access to markets, and financial products tailored to agricultural activities.

Furthermore, animal husbandry and dairy farming saw substantial growth, with incomes increasing by over Rs 12,000. Studies done by Yunus (2007) highlight the role of livestock-based livelihoods in rural economies, where women's involvement in animal husbandry leads to diversified income streams and increased household resilience. Moreover, Desai (2016) found that when NGOs provide skill-building initiatives in such areas, they enable women to tap into local and regional markets, often leading to long-term income stability. Handicrafts, in particular, align with Gupta & Mishra (2019), who identified traditional crafts as a source of sustainable income for rural women, especially when combined with modern market strategies and training. Slathia et al., (2014) reported impact in terms of enhancement towards their general awareness to basic amenities, better education, equality of opportunity, decision making capabilities, freedom of expression, personal security and their exposure to different educational institutions within and outside the state for acquiring latest know-how and technical expertise in various aspects of modern agriculture and subsidiary ventures due to NGO intervention.

Gupta & Yadav (2019) found that NGO-led livelihood programs in Bihar not only increased income but also improved savings patterns among rural women. Their research indicated that women engaged in small-scale enterprises such as papad-making and dairy farming experienced a 50% growth in savings over a two-year period. This financial independence has reduced dependency on male family members and enhanced women's decision-making roles within households. As per Prasad & Kumar (2018), NGO interventions have not only led to income generation but also enhanced women's financial independence and decision-making

power. Their study reported a 50% increase in women's control over household finances post-engagement in NGO-led livelihood initiatives, particularly in dairy and tailoring sectors.

CONCLUSION

The present study highlights the effectiveness of NGO-Led livelihood initiatives on income generation among rural women of Bihar. This study affirms the positive impact of NGO-led livelihood initiatives on rural women's income, expenditure, and savings in fostering economic empowerment. The significant increases in income and savings across various sectors indicate that tailored initiatives, such as vocational training, financial support, and market linkages, can substantially enhance the economic well-being of rural women. The findings reveal that engagement in diverse activities such as tailoring, agriculture, handicrafts, and animal husbandry not only increased income but also improved savings and expenditure management. Tailoring and agriculture emerged as the most impactful sectors, reflecting the potential of skill-based and farming-related interventions to drive sustainable economic growth. Ultimately, these NGO-Led livelihood initiatives play a vital role in fostering economic resilience, promoting self-reliance, and empowering rural women, contributing to broader rural development and poverty alleviation efforts in Bihar.

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Effect of Crop Insurance and Employment Support on Agricultural Households' Well-being: Evidence from India

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HIGHLIGHTS

- Indian farmers jointly follow farm risk management and livelihood diversification to augment their income for better well-being.
- Household and farm-related characteristics influence farmers' decision to participate in PMFBY and MNREGS.
- Involvement in both, PMFBY and MNREGS, have significant and positive impact on household usual consumption expenditure.

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ABSTRACT

Indian farmers jointly follow farm risk management and livelihood diversification to augment their income for better well-being. The uncertainties in climatic conditions and rural employment market pose dangers of income insecurity to already low-incomed farmers. Crop insurance is a promising production risk management technique, which, through Pradhan Mantri Fasal Bima Yojana (PMFBY), seems beneficial in improving Indian farmers' well-being by ensuring financial support during crop loss. Similarly, Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) provide income security by ensuring guaranteed regular employment. This paper strives to contribute to the knowledge related to PMFBY and MNREGS. The Binary Logit Regression results suggest that marginal and small farmers are less involved in both whereas socially marginalized farmers participate more in MNREGS but less in PMFBY. The possession of education, agricultural training and crop loss experience enhance their participation in both. Further, the Propensity Score Matching (PSM) results of all the three different matching methods suggest the positive impact of PMFBY and MNREGS on household usual consumption expenditure. The study suggests to enhance crop insurance adoption by boosting education, agricultural training, and membership in farmer organization. Further, ensuring diverse livelihood opportunities to farmers for their improved well-being.

INTRODUCTION

In climate-posed uncertain situation (Jatav, 2024b; Birthal, 2022), managing the production risks and exploring other livelihood diversification techniques seems most common attempt for the farmers' sustainability in farming (Srinivas & Giridhar, 2023; Vinaya & Tapan, 2023; Jatav, 2024c). Though farmers follow input advices and different crop management strategies to manage the production risks, the uncertain climate fluctuations and resultant losses affect

the yield. The sector demands a robust mechanism targeted for long run to secure the farm incomes (Bharat et al., 2022). For augmenting income by livelihood diversification, farmers generally get involved in unskilled labour activities (Srinivas & Giridhar, 2023). The uncertainty in rural unorganised labour market puts them on the verge of income insecurity (Deininger & Liu, 2019).

Crop insurance is popular and one of the most cost-effective solutions for farm risk management (Nirmal & Babu, 2021). The latest launched crop insurance scheme, i.e. Pradhan Mantri Fasal

Bima Yojana (PMFBY), seems beneficial for farmers due to its attracting features in terms of covering risks, capital and crops and having highly subsidized premium rates (Bharne & Yadav, 2022). For income security, Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) becomes the biggest support with the guaranteed regular employment for the rural people (Nayak, 2012). MGNREGS is a flagship social welfare program aiming at enhancing the livelihood security of rural households by providing at least 100 days of guaranteed wage employment in a financial year to every rural household whose adult members volunteer to do unskilled manual work (Singh, 2013; Bose, 2017).

Both PMFBY and MNREGS, are among the most aspirational income security schemes of the Indian government. Considering MNREGS are the core for poverty eradication (Singh, 2013), and the continuous increase in budget allocation of PMFBY shows the governments' seriousness towards ensuring income security to the vulnerable population. As agriculture is predominantly a rural occupation in India, PMFBY largely overlaps the MNREGS target population, and thus, both schemes have targeted to improve the rural economy. The previous similar studies about crop insurance (Nain et al., 2017; Aditya et al., 2018; BIRTHAL et al., 2020; Cariappa et al., 2020) and MNREGS (Bose, 2017; Deininger & Liu, 2019; Varman & Kumar, 2020) find that they significantly improve the different aspects of farmers' well-being.

Considering the above, this study aims to analyse the determinants and assess the impacts and the extents of the abovementioned governmental security schemes on farmer well-being in India. The variables for the study are selected after a robust literature review and are suggested and used by previous similar studies. The household Usual Consumption Expenditure is considered as an indicator for the respective purpose. Further, analysis of latest available nationwide information broadens the study's scope and makes it unique from the previous studies.

METHODOLOGY

This study was carried out using latest nationwide information about Indian agricultural situation from 77th round of survey conducted by National Sample Survey Office (NSSO). A total 56894 sample rural households were selected by following reliable sampling techniques and most of them were visited twice in different halves of the agricultural year July 2018 – June, 2019. This study used data of households only who were reported on both visits. Subsequently, the metadata was filtered to extract the suitable data for fulfilling the purpose of the study. In this regard, the households who operated land for agricultural production during survey period and had crop insurance facility available under PMFBY, were selected. Further, the outliers were filtered out and 38,521 sample households were considered for final empirical analysis.

This study used two methods in the subsequent steps of statistical analysis. In the first step, the Binary Logistic Models was adopted for investigating the perceived determinants of PMFBY and MNREGS involvement in the sample farmers (Singh, 2020). The logistic regression is most appropriate when estimating the probability of adoption of specific policy is the purpose. The latent models are specified as:

$$PMFBY_i = \beta_0 + \beta_1 HHSIZE_i + \beta_2 ST_SC_i + \beta_3 AGE_i + \beta_4 EDU_i + \beta_5 MARG_SMAL_i + \beta_6 INCOME_i + \beta_7 AGTRNG_i + \beta_8 IRRIGAT_i + \beta_9 FOMBR_i + \beta_{10} INPUTS_i + \beta_{11} CROPLOSS_i + m_i \quad \dots (1)$$

$$MNREGS_i = \beta_0 + \beta_1 HHSIZE_i + \beta_2 ST_SC_i + \beta_3 AGE_i + \beta_4 EDU_i + \beta_5 MARG_SMAL_i + \beta_6 INCOME_i + \beta_7 AGTRNG_i + \beta_8 IRRIGAT_i + \beta_9 FOMBR_i + \beta_{10} INPUTS_i + \beta_{11} CROPLOSS_i + m_i \quad \dots (2)$$

The regressors in the models include households' socio-demographic and farm-related characteristics and their detailed description is provided in the Table 1. The explanatory variables for the study are selected after a robust literature review and are suggested and used by previous similar studies. The regressors shown in the equations are vectors of the individual independent variables. Some of the independent variables are continuous, whereas the rest are categorical. β_0 is a constant term and m_i infers the net effect of ignored variables.

In the subsequent step, the treatment effect of PMFBY and MNREGS on outcome variables representing farmer well-being was assessed. Income and consumption are generally considered for measuring poverty, while the absolute income hypothesis finds consumption as a function of income. Considering the fact that income influences farmers' taste and living conditions (Areef et al., 2021), reported household usual consumption expenditure as an indicator of farmers' well-being.

For this purpose, the Propensity Score Matching (PSM) technique was used. Because simply calculating the mean difference between adopted and non-adopter farmers will result in biased estimates, as the households' characteristics may affect their likelihood of adoption and, ultimately, the outcome results. PSM helped to pair adopters with non-adopter by aligning their distributions across the selected explanatory variables, which was crucial for maintaining the integrity of the comparison (Cariappa et al., 2020). Moreover, the Average Treatment Effects (ATT) were calculated using three distinct matching techniques: Nearest Neighbor (NNM), Radius (RM) and Kernel matching (KM). The ATT equation by assuming the absence of selection bias is specified as:

$$ATT = E [y_i^1 - y_i^0] = E [y_i^1 - y_i^0 | D = 1] = E [y_i^1 | D = 1] - E [y_i^0 | D = 0] \quad \dots (3)$$

Where y_i^1 and y_i^0 denote household usual consumption expenditure when they are adopter and non-adopter of any of our considered policies, respectively. $E [y_i^1 | D = 1]$ represents expected value of impact of participation and $E [y_i^0 | D = 0]$ represents counterfactual outcome. The ATT indicates the change in outcome of the farmers subject to their participation in PMFBY and MNREGS, separately.

RESULTS

Variable description and descriptive statistics

Table 1 depicts the low crop insurance penetration under PMFBY and decent participation in MNREGS. Only 11.06 per cent of total sample agricultural households who had availability of crop insurance under PMFBY insured their crops, while 25 per cent of them participated in MNREGS-related works. The significant differences in the most of the features of treated and control groups for both the treatment variables were reported and

explained by employing t-tests. The t-statistics suggest that PMFBY adopters had increased consumption expenditure than the non-adopters with a significant mean difference of Rs. 436. On the contrary, the mean difference in consumption expenditure between MNREGS participants and non-participants was found insignificant and very low.

The variations in the other features suggest that PMFBY adopters consist of older, more secondary and above educated and better-incomed farmers than the PMFBY non-adopters. Also, Farmers who had more irrigated land, membership of farmer organization, attended agriculture training, spent more on farm inputs and experienced crop loss were significantly more involved in crop insurance under PMFBY. Farmers belonging to socially marginalized categories, lower farmer categories and with larger households were less inclined towards crop insurance. In MNREGS, participation of farmers belonging to socially marginalized and lower farmer category, farmers having membership of farmer organization and agriculture training, were significantly found more in the considered sample. Less participation of farmers with more household members, age, income, irrigated land, and spending on farm inputs, along with educated and loss-experienced farmers, was noted with significant mean difference values. However, these results are estimated on full sample where the presence of selection bias might affect their reliability. To address the selection bias and get the true picture, PSM is employed.

Determinants of PMFBY and MNREGS and estimation of the propensity scores

The Binary Logistic Regression (BLR) results of the models help in analysing the perceived determinants of crop insurance (PMFBY) and MNREGS, respectively (Table 2). The BLR was employed using full sample data to understand the effects of household and farm-related characteristics on farmers participation in PMFBY and MNREGS, separately. The odds ratios and marginal effects for each explanatory variable were estimated in both the

models to interpret the results. For the reliable empirical results, diagnosis of the econometric issues and inspection of goodness-of-fit (GOF) of models were conducted. The mean Variance Inflation Factor (VIF) value of 1.2 negated the presence of multicollinearity while significant p-values of Breusch-Pagan/Cook-Weisberg test indicate that heteroskedasticity exists in both the models. To address the issue, the logistic regression with robust standard errors were employed (Wooldridge, 2013). The significant p-values of Pearson's GOF test for both the models validate the fitness and specification of the considered models.

The results pertaining to determinants of PMFBY and MNREGS suggested that marginal and small farmers were less involved in both of the governmental security programs than their counterparts, while farmers' income status didn't show significant associations. Farmers from socially marginalized strata (ST and SC) were less inclined towards crop insurance but had more participation in MNREGS work with significantly good numbers. Secondary and above educated farmers were more attracted towards crop insurance under PMFBY and less towards unskilled works under MNREGS. Farmers who faced crop loss, insured more but worked less in MNREGS than who didn't. Among other determinants, agriculture training, membership of farmer organization and spendings on farm inputs showed positive, whereas household size showed negative associations in both the cases. Having more irrigated land significantly increased crop insurance adoption, but decreased participation in MNREGS work among the farmers.

The socio-demographic characteristics were primary determinants of crop insurance adoption, as well as participation in MNREGS. The calculated marginal effects indicated that an increase in number of family members decreases the probability of farmers participation in crop insurance (PMFBY) and MNREGS by 0.6 per cent (for both). Further, if a farmer belongs to ST or SC category, she/he has 4.4 per cent less probability of adopting crop insurance but 15.5 per cent more probability of participation in

Table 1. Variations in household features by involvement status in PMFBY and MNREGS

Variable	Description	PMFBY participation (1 = Yes, 0 = No)			MNREGS participation (1 = Yes, 0 = No)		
		Yes (4,263)	No (34,258)	t-test	Yes (10,019)	No (28,502)	t-test
Outcome Variable							
Consumption Expenditure	Continuous	8615.40	8179.34	436.06***	8241.66	8222.66	18.99
Explanatory Variable							
Household Size	continuous	4.53	4.727	-0.199***	4.60	4.74	-0.144***
Social Category	SC/ST = 1; otherwise = 0	0.22	0.36	-0.147***	0.51	0.29	0.216***
Age	continuous	51.68	50.19	1.489***	49.49	50.65	-1.16***
Education	Above from secondary = 1; otherwise = 0	0.30	0.24	0.063***	0.18	0.267	-0.091***
Farmer Category	Marginal/small farms = 1; otherwise = 0	0.30	0.580	-0.277***	0.57	0.54	0.030***
Income	continuous	13014.22	10387.66	2626.56***	9952.12	10933.61	-981.49***
Agriculture Training	1 = Yes, otherwise = 0	0.04	0.017	0.021***	0.02	0.02	0.003**
Irrigation	Continuous	2.15	1.067	1.08***	0.77	1.33	-0.569***
Farmer Org. Member	1 = Yes, otherwise = 0	0.08	0.038	0.041***	0.06	0.04	0.024***
Farm Input	Continuous	5507.60	2494.94	3012.66***	2293.16	3016.47	-723.31***
Crop Loss Experience	1 = Yes, otherwise = 0	0.62	0.48	0.14***	0.46	0.51	-0.048***

Source: Authors' calculation based on NSSO 77th round survey data.

Note: ***, ** and * denote 1%, 5% and 10% level of significance of p-values, respectively.

Table 2. Determinants of PMFBY and MNREGS

Variable	PMFBY			MNREGS		
	Coefficient (Robust S.E.)	Odds Ratio (Robust S.E.)	Marginal Effects (Robust S.E.)	Coefficient (Robust S.E.)	Odds Ratio (Robust S.E.)	Marginal Effects (Robust S.E.)
HH Size	-0.067*** (0.008)	0.935*** (0.008)	-0.006*** (0.001)	-0.035*** (0.006)	0.965*** (0.006)	-0.006*** (0.001)
Social Category	-0.516*** (0.041)	0.597*** (0.025)	-0.044*** (0.003)	0.801*** (0.025)	2.228*** (0.056)	0.155*** (0.005)
Age	0.001 (0.001)	1.001 (0.001)	0.000 (0.000)	-0.005*** (0.001)	0.995*** (0.001)	-0.001*** (0.000)
Education Level	0.075* (0.039)	1.078* (0.042)	0.007* (0.004)	-0.433*** (0.031)	0.649*** (0.020)	-0.074*** (0.005)
Farmer Category	-0.883*** (0.04)	0.414*** (0.017)	-0.080*** (0.004)	-0.146*** (0.027)	0.864*** (0.023)	-0.026*** (0.005)
HH Income	0.000 (0.000)	1.000 (0.000)	0.000 (0.000)	0.000 (0.000)	1.000 (0.000)	0.000 (0.000)
Agriculture Training	0.488*** (0.1)	1.630*** (0.162)	0.052*** (0.012)	0.181** (0.090)	1.199** (0.107)	0.034** (0.017)
Irrigation	0.039*** (0.009)	1.040*** (0.010)	0.004*** (0.001)	-0.188*** (0.012)	0.829*** (0.010)	-0.034*** (0.002)
Farmer Org. Member	0.461*** (0.071)	1.585*** (0.113)	0.049*** (0.009)	0.718*** (0.055)	2.050*** (0.113)	0.146*** (0.012)
Farm Inputs	0.000*** (0.000)	1.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	1.000*** (0.000)	0.000*** (0.000)
Crop Loss	0.498*** (0.035)	1.645*** (0.057)	0.045*** (0.003)	-0.170*** (0.024)	0.844*** (0.020)	-0.031*** (0.004)
Constant	-1.798*** (0.088)	0.166*** (0.015)		-0.612*** (0.063)	0.542*** (0.034)	
Wald chi ²	1856.7	1856.7		2156.58	2156.58	
Prob> chi ²	0.000	0.000		0.00	0.00	
Pseudo R ²	0.0829	0.0829		0.0542	0.0542	
Observations	38,521	38,521		38,521	38,521	
<i>Diagnostic Statistics</i>						
Mean VIF	1.20			1.20		
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity	0.00			0.00		
Pearson GOF test	0.00			0.00		

Source: Authors' calculation based on NSSO 77th round survey data.

Note: Robust Standard errors are in parenthesis, ***, ** and * denote 1%, 5% and 10% level of significance of p-values, respectively.

unskilled work under MNREGS. The variable representing age shows significant association only for MNREGS and suggest that an additional year of farmers age decrease the participation in MNREGS by 1 per cent. Education is a critical influencer of farmers' decision making in adopting farm risk management, as well as livelihood diversification strategy. The results indicated that possession of secondary and above education significantly increases probability of farmers' involvement in PMFBY by 7 per cent, but decreased the probability of their involvement in MNREGS by 7.4 per cent. Subsequently, the calculated marginal effects regarding farmer category indicate that there is an 8 and 2.6 per cent less probability of participation of marginal and small farmers in crop insurance (PMFBY) and MNREGS, respectively.

Table 2 depicts the significant association between farm-related characteristics and outcome variables (PMFBY and MNREGS). The results show that the probabilities of farmers' participation in PMFBY and MNREGS increase by 5.2 and 3.4 per cent if they

have attended any formal training in agriculture. Further, having more irrigated land increased probability of crop insurance adoption by 4 per cent but decreases the probability to participate in MNREGS by 3.4 per cent. The membership of farmer organization increases the likelihood of farmers' involvement in both, PMFBY and MNREGS. The marginal effect results suggest that farmers who were members of any registered farmer organization had 4.9 and 14.6 per cent more probability of involvement in PMFBY and MNREGS, respectively. However, variable representing farm inputs show negligible but significant association and indicate that farmers who spend more for farm inputs have slight better chances of participation in PMFBY and MNREGS. Lastly, the crop loss possesses positive marginal values for PMFBY but negative for MNREGS. The marginal values of crop loss indicated that the farmer who have experienced crop loss had higher probability to insure their crops under PMFBY by 4.5 per cent but 3.1 less probability to perform unskilled work under MNREGS.

Table 3. Treatment effect of PMFBY and MNREGS on household usual consumption expenditure

Outcome Variable	Matching Method	Treatment Variable	Participants	Non-Participants	ATT (S.E.)
Household Usual Consumption Expenditure (CONSEXP)	Nearest-Neighbor (k = 1)	PMFBY	8615.40	8410.28	205.12*** (78.8)
		MNREGS	8241.66	7747.58	494.07*** (52.88)
	Radius (caliper = 0.05)	PMFBY	8615.40	8464.08	151.32** (56.03)
		MNREGS	8241.66	7792.38	449.28*** (39.03)
	Kernel (b width = 0.06)	PMFBY	8615.40	8469.44	145.97** (56.08)
		MNREGS	8241.66	7787.54	454.11*** (39.05)

Source: Authors' calculation based on NSSO 77th round survey data.

Note: Standard errors are in parenthesis, ***, ** and * denote 1%, 5% and 10% level of significance of p-values, respectively.

Impact of PMFBY and MNREGS on household usual consumption expenditure

The Propensity Score Matching (PSM) was utilized to address the selection bias and estimate the accurate impacts of involvement in PMFBY and MNREGS on farmer households' usual consumption expenditure. The PSM addressed the selection bias by making pairs of a treated and an untreated farmer using the similarities in their observed household characteristics. It then measured the mean difference of usual consumption expenditure between treated and untreated groups. To check the robustness of the findings, the Average Treatment Effects on the treated (ATT) were calculated using three distinct matching techniques: Nearest Neighbour (NNM), Radius (RM) and Kernel matching (KM). The ATT values laid out in Table 3 show the consistency of estimators with statistically significant p-values.

The results depict that the farmers who adopted crop insurance under PMFBY and faced crop loss had an average of Rs. 205 more monthly household usual consumption expenditure than one who didn't adopt and faced crop loss. The results obtained from other matching methods have minor discrepancies only. Similarly, MNREGS significantly increases the monthly household usual consumption expenditure by an average of Rs. 494 among its participants. The other matching methods indicate similar ATT for MNREGS and validated the reliability of the calculated results. The ATT or mean differences pertaining to MNREGS are entirely different than the results obtained using t-test on usual consumption expenditure. It showed the adequacy of PSM in impact analysis of any treatment or policy.

DISCUSSION

Most of the variables used in the empirical analysis showed desired results by indicating significant associations. Though many of them match with the findings of previous studies, few differ in direction, for which suitable justifications were presented. The social and economic status of farmer were among the most important aspects which largely affect their involvement in governmental security programs. Households having larger farms have better risk-managerial capacity, thus, tend to insure more against small land-

owing farmers who, despite being more risk averse, tend not to insure (Champonnois & Erdlenbruch, 2021). The results of this study justify this argument by showing lesser likelihood of crop insurance adoption under PMFBY among marginal and small farmers than others. However, the results pertaining to MNREGS were against the popular premise that landless and smallholders are more engaged in MNREGS due to limited alternative livelihood options (Azam, 2012). A vast range of landholders attached with '0' values in binary variable 'farmer category' and corrupt practices leading to fake participation in MNREGS (Deshingkar et al., 2005) might be the reasons behind these opposite results.

The social category largely overlaps the farmers' economic status (Wu et al., 2023) and possess similar arguments that smallholders were generally less involved in PMFBY but more in MNREGS. The results followed the existing premises and suggest that the ST and SC farmers were less likely to cover with crop insurance their crops, but more likely to work under MNREGS. Further, education influences farmers' on-farm and employment choices (Jatav, 2024). Educated farmers were more attracted to crop insurance due to better financial understanding of crop insurance mechanisms (Senapati, 2020), whereas less-educated farmers participate more in MNREGS due to restricted employment opportunities in other sectors (Joshi et al., 2017). This study too, find that secondary and above educated farmers secure (crop insurance) their crops more but perform the unskilled works under MNREGS less than their counterparts. Our results are in line with the arguments that higher expenses to run bigger households decreases farmers chances of spending on insurance premiums (Hossain et al., 2022). These results have aligned with findings of our study

The farm related characteristics play important role in farmers' decision-making in the context of farm investments and livelihood strategies. Farmers having better access to agriculture extension services were more attracted towards crop insurance (Sadati et al., 2010). The findings suggest that the farmers with membership of any registered farmers organization tend more to participate in PMFBY and MNREGS. Such membership enhanced their exposure to knowledge and awareness about government policies, markets, and weather conditions, and help them to make better choices (Botzen et al., 2009).

Higher farm investments show farmers' positive attitude toward farming and concerns about possible capital losses (Wang et al., 2016). However this study finds that farmers who spend more on farm outputs execute better for securing their farm capital through PMFBY as well as diversify livelihood through MNREGS. The farmers who faced crop loss seem more interested to secure their crops and match the argument that the crop loss experiences contribute in making them more risk averse (Aditya et al., 2018).

The results pertaining to PMFBY and MNREGS follow the findings of previous such studies and report significant and positive impact of PMFBY and MNREGS on agricultural households' well-being. The household usual consumption expenditure represents the household well-being as all the income generation efforts ultimately lead towards smoothening the overall consumption. Previous studies have reported crop insurance's positive impact on per capita consumption expenditure (Biswal & Bahinipati, 2023), income (BIRTHAL et al., 2022) and negative impacts on outstanding debt (Cariappa et al., 2020). Similarly, MNREGS' role in enhancing expenditure on income (Deininger & Liu, 2019), nutritious food consumption (Bose, 2017) and durable goods (Varman & Kumar, 2020) was observed.

CONCLUSION

The socio-demographic and farm-related characteristics of households affect their participation in PMFBY and MNREGS. Giving farmers a strong way to deal with production risks in farming and making sure they have regular ways to make extra money and improve their health are important for increasing their income and happiness, and making farmers more aware of crop insurance and making the insurance environment stronger can help increase coverage. Helping farmers find other ways to make money based on their skills will definitely improve their well-being; Increasing education, agricultural training, and membership in farmer organizations has been suggested as a way to get more farmers covered by crop insurance; and making landowners more aware of PMFBY is important for getting more of them to sign up for it, which means better advertising and programs like door-to-door policies are also important to help landowners deal with the problems they're facing right now.

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Assessment of Beekeeping Knowledge among Farmers in Haryana

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HIGHLIGHTS

- Beekeeping significantly enhances rural livelihoods by increasing income and supporting sustainable agricultural practices.
- Literacy and education positively influence the adoption of modern beekeeping practices and honey production efficiency.
- Beekeeping supports biodiversity conservation and sustainable rural livelihoods with minimal capital investment.

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ABSTRACT

The Indian economy, heavily reliant on agriculture, faces challenges due to increasing population pressure and declining landholding sizes, pushing farmers to diversify their income sources. Beekeeping, requiring minimal capital investment and leveraging natural resources like nectar and pollen, emerges as a viable alternative. This study, conducted in Kaithal, Kurukshetra, and Karnal districts of Haryana, aimed to assess farmers' knowledge of beekeeping practices. A total of 150 respondents were surveyed using structured interviews and secondary data sources. The results revealed that most beekeepers had a moderate to high knowledge of various aspects of beekeeping, including honey production, bee flora, and biological aspects. Socio-economic factors such as age, education, social participation, and media exposure significantly influenced knowledge levels. Beekeeping not only enhances crop productivity through pollination but also offers employment opportunities, making it an essential strategy for rural development. The study emphasizes the potential of beekeeping in uplifting smallholder farmers and mitigating the limitations of traditional agriculture.

INTRODUCTION

The Indian economy is deeply rooted in agriculture; with over 60 per cent of the population relying on it as their primary source of livelihood. But as a result of growing population pressure and industrialisation, the amount of land held per person is steadily declining. Consequently, it has become increasingly challenging for landless, marginal, and small farmers, as well as unemployed individuals, to fulfil their family's domestic needs. Under such circumstances, farmers have to adopt for some other to uplift their income. Among the enterprises in agricultural sector, bee farming is one of that smart agricultural enterprise that requires minimal capital investment as compared to other related activities (Mishra et al.,

2024). Additionally, it does not require any additional raw material as same is provided by the nature in the form of nectar and pollen. Anybody with technical skills and enthusiasm can engage in this type of entrepreneurship, regardless of their age, gender, level of education, or ownership of land (Kumar et al., 2022). In addition to producing honey and other valuable bee products (such as wax, royal jelly, propolis, pollen, venom, etc.), honey bees (Hymenoptera: Apidae) play a more significant ecological role as the most reliable and effective pollinators of flowering plants and trees, which increases crop productivity (both quantitatively and qualitatively) and maintains plant diversity. In agricultural crops, about ninety per cent of pollination is being carried out by the bees only, and

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result in about thirty-three per cent increase in total production of agricultural and fruits crops and India occupies sixth position among the top ten honey producing countries in the world (Kumar & Patel, 2019). Beekeeping is an excellent source of employment for the rural unemployed youth and currently approximately 2,50,000 farmers in India are employed through beekeeping (Kumar et al., 2022). Moreover, honey bees significantly enhance the yield of agricultural and horticultural crops through effective pollination, while also improving the quality of the produce.

Beekeeping plays a crucial role in diversifying and increasing the income of Indian smallholder farmers and landless youth. Given the challenges posed by depleting natural resources and the reduced profitability of traditional agriculture, nutrition sensitive agriculture like beekeeping holds great potential to uplift the economy of Indian farmers (Mishra et al., 2024). The introduction of the honey bee species *Apis mellifera* to India has revolutionized the beekeeping industry, sparking a remarkable “honey revolution” across the country. In Haryana, successful beekeeping with this exotic species began in 1987, and today, it has become a thriving enterprise, providing livelihoods to many.

METHODOLOGY

The current research was carried out in the meticulously selected Kaithal, Kurukshetra and Karnal districts of Haryana in 2023 utilizing an ex-post facto research design. The districts were chosen on purpose because of its abundant and varied bee keeping, which are perfect for scientific bee rearing. From Kaithal district, fifty respondents were selected at random from the villages namely Machheredi, Kharkara, Riwad, Kakeri, Salempur, Bata and Deohra whereas from Kurukshetra district fifty respondents were selected randomly from the villages namely Charuni Jattan, Ghararsi, Barna, Jhandheri, Thanesar and Shahbad and from Karnal district fifty respondents were selected randomly from the villages namely Budheri, Santri, Khera, Seir, Gheer and Choura. Thus, 150 farmers constituted the respondents to the study by simple random sampling technique.

A planned interview schedule designed especially for the study and direct observation techniques helped get primary data. The government, sectors, and gramme panchayats’ official records provided secondary data. The dependent variable, knowledge of the respondents regarding beekeeping, was employed using the approach outlined by (Boora et al., 2023). Scores of 2, 1, and 0 were assigned to full, partial, and no knowledge, respectively. Knowledge quotients were calculated from raw scores to gauge the overall knowledge level. Thus, after computing the individual knowledge quotient scores, the respondents were categorized into three groups. The relationship between two categorical variables of such independent variables and knowledge level was checked by implementing a non-parametric test of chi-square value and coefficient of contingency estimation to draw a conclusion.

RESULTS

Beekeepers’ knowledge about different aspects of beekeeping

The results depicted in Table 1 depicts knowledge of beekeepers of different districts in general aspects of beekeeping.

The results revealed that majority of the beekeepers possessed highly knowledge about water needs of bee and identification of bees in the general aspects of beekeeping. In management aspects, the majority of farmers have high knowledge about best season for bee keeping and protection of boxes from robbing whereas in honey production aspects, majority had high knowledge about exclusion of queen bee and about extraction of honey. In the case of bee flora aspects of beekeeping, majority of farmers had high knowledge about maize as a good source of flora and about honey bees collect enough nectar during the month of January. Regarding bee breeding aspects, majority had knowledge about maximum number of eggs were laid by queen bees and young queen lay a greater number of eggs than old queen. In case of biological aspects, majority of farmers had high knowledge about life cycle of honey bee and about body parts of honey bees.

Level of knowledge of beekeeping among farmers of Haryana

The data in Table 2 clearly revealed that nearly maximum number of the respondents (46%) demonstrated a moderate level of knowledge about beekeeping, while approximately two-fifths (38%) exhibited a high level of expertise, and 16% had limited knowledge in the field.

Socio-economic variables and level of knowledge of bee keeping in different districts

The data in Table 3 depicts that association between level of knowledge of beekeeping among farmers of Haryana and independent variables namely age, social participation, mass media exposure and socio-economic status were found highly significantly associated at chi-square value of 19.949, 20.318, 13.860 and 14.376 respectively. Analysis clearly revealed that level of education was found significantly associated with level of knowledge at chi-square value of 13.594 whereas, the independent variables namely caste, subsidiary occupation, size of landholding, type of family, size of family and annual income were not found significantly associate with level of knowledge.

DISCUSSION

The study reveals some remarkable trends in the knowledge of beekeeping among farmers in the Kaithal, Kurukshetra, and Karnal districts of Haryana. A reasonable proportion of the respondents, ranging from moderate to high, represent a growing awareness of potential supplementary livelihood sources in such practices. The findings are in line with (Kumar et al., 2020) However, variations in knowledge levels among farmers suggest the influence of factors such as education, social exposure, and prior experience in agricultural enterprises. One key relationship highlighted in the study is the positive correlation between education and beekeeping knowledge. Farmers with higher education levels tend to adopt modern techniques and manage their enterprises more effectively. This is in line with the findings of Yusuf et al., (2017) & Kumar et al., (2019), which indicated that higher education levels have a positive effect on the adoption of modern beekeeping practices. Also, age and experience in beekeeping are directly proportional to the level of knowledge acquired, and thus hands-on involvement would increase learning as is supported by Patel et

Table 1. District wise percentage of beekeepers' knowledge about different aspects of beekeeping (n=150)

Different aspects of knowledge	Full knowledge	Partial knowledge	No knowledge	Mean Score
General aspects				
Identification of queen, worker, drone and Italian honeybees	92(61.33)	27(18.00)	31(20.67)	2.40*
Drone bees are fatter than worker bees	33(22.00)	97(64.67)	20(13.33)	2.08
Worker bee is sharp	110(73.33)	15(10.00)	25(16.67)	2.56*
Drone bees do not harvesting	102(68.00)	28(18.67)	20(13.33)	2.48*
Water is important for bees	120(80.00)	15(10.00)	15(10.00)	2.70*
Guarding of boxes by workers bees	96(64.00)	25(16.67)	29(19.33)	2.46*
Identification of Indian honey bees	35(23.33)	90(60.00)	15(16.67)	2.00
Collection of pollen by worker bees	85(50.00)	35(23.33)	30(20.00)	2.36*
Number of queen bees in a colony	109(72.67)	21(14.00)	20(13.33)	2.59*
Swarming of bees during April	83(55.33)	36(24.00)	31(20.67)	2.34*
Sugar present in honey	26(17.33)	104(69.33)	14(9.34)	2.01
Season for increasing of boxes	102(68.00)	24(16.00)	24(16.00)	2.48*
Age of worker bees	25(16.67)	96(64.00)	29(19.33)	1.97
Monsoon season for bees	90(60.00)	30(20.00)	30(20.00)	1.80
Preference of domestic bees for comb making	85(56.67)	35(23.33)	30(20.00)	2.36*
Knowledge of nectar collected by bees	109(72.66)	21(14.00)	20(13.34)	2.59*
Types of honeybees	83(55.33)	36(24.00)	31(20.67)	2.34*
Overall Mean score 2.32				
Management aspects				
Sugar syrup feeding to boxes	31(20.67)	92(61.33)	27(18.00)	2.02
Packing of boxes during winter	33(22.00)	97(64.66)	20(13.34)	2.08*
Robbing problem	15(10.00)	110(73.33)	25(16.67)	1.83
Checking of boxes during summer	28(18.67)	102(68.00)	20(13.33)	1.98
Optimum time to start beekeeping	15(10.00)	120(80.00)	15(10.00)	2.00
Checking of boxes during winter	25(16.67)	96(64.00)	29(19.33)	1.96
Placement of boxes during winter	29(19.33)	91(60.67)	30(20.00)	1.92
Protection of boxes from robbing	85(56.67)	36(24.00)	29(19.33)	2.37*
Benefits of winter packing	21(14.00)	109(72.67)	20(13.33)	2.01
Hive tool	36(24.00)	83(55.33)	31(20.67)	2.03
Best season for bees	104(69.33)	26(17.33)	14(9.34)	2.52*
Giving feed to boxes during offseason	20(13.33)	107(71.33)	23(15.34)	1.98
Optimum number of boxes to start beekeeping	24(16.00)	98(65.33)	28(18.67)	1.97
Time to giving feed to colonies	25(16.67)	96(64.00)	29(19.33)	1.90
Robbing during rainy season	27(18.00)	92(61.33)	31(20.67)	1.97
Method used to decrease the population of drones	33(22.00)	97(64.67)	20(13.33)	2.08*
Row to row distance	25(16.67)	110(73.33)	15(10.00)	2.06*
Box to box distance	28(18.67)	102(68.00)	20(13.33)	2.05*
Overall Mean score 2.04				
Honey production aspects				
Extraction of honey	93(62.00)	27(18.00)	30(20.00)	2.35*
Queen excluder	87(58.00)	34(22.67)	29(19.33)	2.38*
Maturity of honey	31(20.67)	99(66.00)	20(13.33)	2.07
Production of honey	43(28.67)	75(50.00)	32(21.33)	2.05
Benefits of queen excluder	100(66.67)	30(20.00)	20(13.33)	2.53*
Freezing of honey	27(18.00)	100(66.67)	23(15.33)	2.04
Wax production	31(20.67)	99(66.00)	20(13.33)	1.87
Purity of honey	20(13.33)	105(70.00)	25(16.67)	1.83
Consumption of honey by bees for production of wax	38(25.33)	92(61.33)	20(13.34)	2.05
Overall Mean score 2.13				
Bee flora aspects				
Migration of boxes	89(59.33)	32(21.33)	29(19.34)	2.40*
Whether bees destroy the flowers	15(10.00)	35(23.33)	100(66.67)	1.36
Availability of flora for bee during March-April	83(55.34)	33(22.00)	34(22.66)	2.32*
Importance of pollen or bees	21(14.00)	110(73.33)	19(12.67)	2.01
Things collected by bee from flowers	36(24.00)	85(56.66)	29(19.34)	2.04
Maize as a good source of flora	105(70.00)	25(16.67)	20(13.33)	2.56*
Honey bees collect enough nector during January	102(68.00)	30(20.00)	18(12.00)	2.55*
Which crop produce more honey	22(14.66)	96(64.00)	32(21.34)	1.93
Pollen collected by worker bees	30(20.00)	95(63.33)	25(16.67)	2.03
Overall Mean score 2.13				

Table 1 contd....

Different aspects of knowledge	Full knowledge	Partial knowledge	No knowledge	Mean Score
Bee enemies' aspect				
Protection of bees from ants	33(22.00)	97(64.67)	20(13.33)	2.08*
Damage of wax moth	40(26.66)	78(52.00)	32(21.34)	2.05
Damage of varroa mite	50(33.33)	85(56.67)	15(10.00)	2.23*
Damage of green sparrow	62(41.33)	48(32.00)	40(26.67)	2.14*
Season of incidence of wax moth	31(20.67)	93(62.00)	26(17.33)	2.03
Control measures for varroa mite	27(18.00)	98(65.33)	25(16.67)	2.01
Incidence of wax moth	38(25.33)	89(59.33)	23(15.34)	2.04
Thaisac brood disease of bees	55(36.67)	36(24.00)	59(39.33)	1.99
Overall mean score 2.07				
Bee breeding aspects				
Young queen lay a greater number of eggs than old queen	99(66.00)	20(13.33)	31(20.67)	2.45*
Purchasing of bee sand young mated queen	101(67.33)	34(22.67)	15(10.00)	2.57*
Swarming by young queen	47(31.33)	85(56.67)	18(12.00)	2.19
Laying worker bees	38(25.33)	94(62.67)	18(12.00)	2.13
Laying of eggs by queen bee	34(22.67)	78(52.00)	38(25.33)	1.97
Maximum number of eggs laid by queen bees	119(79.33)	10(06.67)	21(14.00)	2.65*
Age of queen bee	102(68.00)	23(15.33)	25(16.67)	2.44*
Mating of queen bee by drones	22(14.67)	89(59.33)	39(26.00)	1.88
Number of eggs queen lays per cell	36(24.00)	89(59.33)	25(16.67)	2.07
Method of queen rearing	45(30.00)	67(44.67)	38(25.33)	2.04
Overall Mean score 2.23				
Bee biology aspects				
Rearing of queen from eggs	47(31.33)	87(58.00)	16(10.67)	2.20
Rearing of worker bee from eggs	45(30.00)	85(56.67)	20(13.33)	2.16
Rearing of drone from eggs	45(30.00)	80(53.33)	25(16.67)	2.13
Life cycle of honey bee	95(63.33)	35(23.33)	20(13.34)	2.43*
Body parts of honey bees	76(50.66)	56(37.33)	18(12.00)	2.38*
Overall mean score 2.26				

Figures in parentheses denote percentage; Responses were multiple

Table 2. Level of knowledge of beekeeping among farmers of Haryana (n=150)

Level of knowledge	Frequency
Low (76-126)	24 (16.00)
Moderate (127-177)	69 (46.00)
High (178-228)	57 (38.00)

Figures in parentheses denote percentage

Table 3. Association between socio-economic variables and knowledge of bee keepers in different districts of Haryana

Socio-economic variables	Chi-Square value (χ^2)	Coefficient of contingency (C)
Age	19.949**	0.343
Caste	3.959	0.160
Level of education	13.594*	0.288
Subsidiary occupation	9.879	0.249
Size of land holdings	10.323	0.254
Type of family	1.632	0.104
Size of family	9.663	0.246
Annual family income	3.825	0.158
Social participation	20.318**	0.345
Mass media exposure	13.860**	0.291
Socio-economic status	14.376**	0.296

al., (2015), who noted that experience in agricultural enterprises develops practical skills. Social involvement, which involves membership in farmers' groups and mass media, strengthens knowledge. In this regard, it seems that community-based activities and the dissemination of information play an important role in findings of (Raina et al., 2017; Kumari & Singh, 2022) concerning the role of community-based initiatives and mass media in the dissemination of information. Findings are in line with other previous research indicating that beekeeping contributes to the rural livelihoods and biodiversity conservation substantially (Chauhan et al., 2020; Kumar et al., 2022). A generalization that can be derived from the data is that beekeeping is perceived as a low-investment, high-benefit enterprise. Farmers widely acknowledge its role in enhancing crop productivity through pollination, which aligns with studies by Gill et al., (2015) & Meena et al., (2017), which emphasize the ecological importance of bees. Exceptions to this generalization include farmers in remote areas who lack adequate resources, as noted by Ramesh et al., (2020). Although the study's findings broadly align with existing literature, there is disagreement on the degree of institutional support needed. Contrary to studies that propose reliance on heavy government subsidies (Khan et al., 2018), this study proposes community-led approaches and training programs as more viable alternatives.

CONCLUSION

Beekeeping holds great promise to improve the livelihoods of Indian farmers, especially in Haryana, where knowledge levels of beekeepers are moderate to high. Ecological and economic benefits associated with this enterprise include crop productivity enhancement, income diversification, and employment opportunities. The age factor, education level, and social participation are all important determinants of knowledge acquisition, suggesting that targeted training programs and awareness campaigns should be part of the efforts. However, with all these benefits, problems such as limited resources and technical know-how remain. Thus, government support for beekeeping, technical training, and community-based initiatives can help overcome the mentioned challenges. Beekeeping represents a sustainable, low-investment enterprise that can play a significant role in rural economic development and environmental sustainability.

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Cluster Analysis-Based Discernment of Farmers' Typologies and Climate Change Adaptation Strategies among Rural Women

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HIGHLIGHTS

- Identified four farmer clusters emphasizing diverse climate adaptation strategies through K-means clustering.
- Highlighted cluster-specific priorities: agronomic practices, mechanization and technology integration, soil and water management practices, and sustainable and eco-friendly practices.
- Recommended targeted interventions for climate resilience and empowerment of rural women farmers.

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ABSTRACT

Climate change poses significant challenges to agriculture, particularly in vulnerable regions like Uttar Pradesh and Haryana, where women contribute significantly to the agricultural workforce. They play a pivotal role in adopting climate-smart adaptation strategies ensuring food security, economic stability, and environmental sustainability. The study was conducted in 2024 to explore women farmers' adaptation strategies using K-means clustering. Based on their prioritization of 16 strategies, randomly selected 100 women farmers were found to belong in four distinct clusters. Cluster 1 emphasized crop and agronomic practices, changing planting dates, crop rotations, and Direct Seeded Rice (DSR). Cluster 2 prioritized mechanization and technology integration, raised-bed planting and laser levelling. Cluster 3 focused on soil and water management and harvesting practices, zero tillage, crop diversification, while Cluster 4 preferred sustainable practices as mulching, Integrated Pest Management (IPM), and bio-fertilizers. The analysis underscores the need for targeted agricultural and extension interventions tailored to each cluster's unique priorities. Strategies include promoting climate-resilient crops, precision agriculture, conservation techniques, and bio-inputs. Extension approaches such as field demonstrations, custom hiring centers, and capacity-building workshops are recommended. These findings highlight importance of cluster-specific strategies to empower women farmers and enhance their resilience to climate change, contributing to sustainable development goals.

INTRODUCTION

Agricultural production systems worldwide are expected to undergo transformations in response to changing climatic conditions, as evidenced by studies linking recent variations in crop yields to the

impacts of climate change (Harikrishna et al., 2019; Ray et al., 2015; Sarkar et al., 2022). The Economic Survey 2022-23 highlights that 65 per cent of India's population resides in rural areas, with nearly 47 per cent depending on agriculture for their livelihoods. Agriculture is the primary income source for 70 per cent of rural households, of

which 82 per cent are small and marginal farmers. Sustainable development, balancing human well-being with ecological constraints, is critical. The UN's Human Development Index (HDI) and Ecological Footprint measure progress toward this goal. The 2030 Agenda for Sustainable Development, encompassing 17 goals, underscores the significance of gender equality. Empowering rural women, who constitute 80 per cent of India's agricultural workforce, is crucial for economic growth, food security, and poverty reduction (Renu, 2023). India's Azaadi Ka Amrit Mahotsav, celebrating 75 years of independence, emphasizes the empowerment of women, acknowledging their pivotal role in rural development. Climate change, characterized by rising global temperatures and extreme climatic events, poses a significant threat to ecosystems and human livelihoods. Its impacts are felt worldwide, but rural communities, especially women, are among the most vulnerable (Bharat et al., 2022).

Rural women face significant challenges, including financial instability, socio-economic vulnerabilities, and climate variability, all of which exacerbate poverty. Climate change disproportionately affects vulnerable populations reliant on agriculture. In India, droughts impact over 21 per cent of the land, and climate-induced health issues and economic losses are projected to rise by 2030 (Chuphal et al., 2024). Addressing these challenges requires prioritizing SDG 5 – Gender Equality. Despite efforts like the Drought Early Warning System (DEWS), action remains urgent. Women's vulnerability is compounded by poverty, limited resource access, and socio-cultural norms, particularly in rural areas where they spend considerable time fetching water and firewood. Climate-related events like droughts and floods heighten these burdens. Studies show that women from underprivileged backgrounds in arid regions are disproportionately affected (Yadav & Lal, 2018). Limited education, institutional support, and socio-cultural constraints further hinder adaptation. However, women also act as agents of change, applying knowledge and adaptive strategies. Initiatives such as community seed banks and rainwater harvesting empower women to manage resources sustainably, enhancing resilience and social status.

Zhang et al., (2020) identified barriers to adaptation, inadequate technology, financial constraints, and poor infrastructure, noting socio-economic factors like education, experience, and gender influenced strategies. Health-related climate risks led to financial adaptations, while agricultural concerns prompted diversification. Goli et al., (2020) found that threat and coping appraisals shaped adaptation, severity perceptions affecting threat appraisal and response costs influencing coping. Djoudi & Brockhaus (2011) highlighted gendered adaptation differences, where male migration increased women's workloads. Similarly, Khalil et al., (2020) observed that male migration in Gabura empowered women to adopt innovations by collaborating with aid agencies & leveraging social capital.

This study seeks to understand the diverse characteristics and climate change adaptation strategies of female farmers in rural areas through cluster analysis, offering insights to enhance gender-sensitive adaptation strategies for sustainable development.

METHODOLOGY

The study was conducted in Uttar Pradesh and Haryana, chosen for their high vulnerability to climate change. Uttar Pradesh,

with over 250 million people, 58,000 Gram Panchayats, and 750 Urban Local Bodies, frequently faces floods, cold waves, and heat waves. Approximately 50 of its 75 districts are highly to moderately vulnerable. Haryana, a semi-arid state integral to India's Green Revolution, has experienced severe climate impacts, including damage to 347,117 hectares of agricultural land (Kaur et al., 2021). Two districts were randomly selected from each state: Mathura in Uttar Pradesh and Nuh in Haryana. A sampling frame of women farmers engaged in agriculture was created, and 50 farmers from each district were selected through simple random sampling.

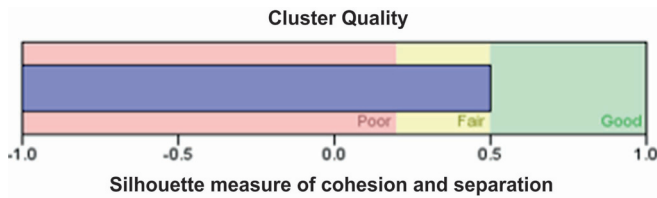
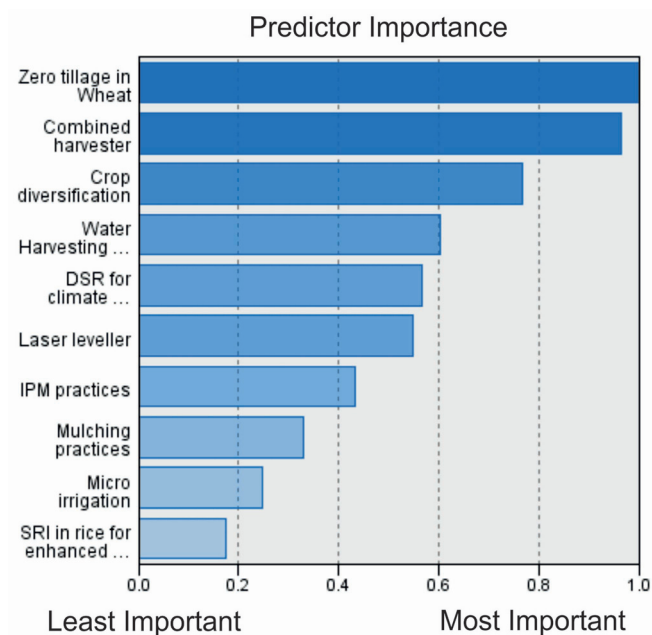
Primary data was collected through personal interviews and Focus Group Discussions (FGDs), which identified key variables. A structured questionnaire captured socio-personal characteristics and climate-smart adaptation strategies adopted by respondents. Adaptation strategies were scored on a binary-ordinal scale, with '2' assigned to practiced strategies and '1' to unpracticed ones. These socio-personal variables were closely tied to the adaptation measures adopted for mitigating climate change effects. Cluster analysis served as the primary method to achieve the study's objectives. Multiple iterations were conducted to identify the optimal number of clusters by analyzing variations in mean distances between initial clusters (Blashfield & Aldenderfer, 1978). The non-hierarchical K-means algorithm was utilized to group farmers with similar adaptation strategies. This approach enabled the identification of distinct target groups, allowing for the promotion of climate-smart practices tailored to their needs, ultimately enhancing their capacity to adopt effective strategies for climate change adaptation (Mabon et al., 2021). The K-means algorithm is a widely used clustering method that generates a single set of flat clusters without hierarchical organization. It is suitable for datasets with distinct groups but requires the number of clusters (K) to be predetermined. This selection often involves trial and error due to its subjective nature. Therefore, for clustering, both the hierarchical and non-hierarchical clustering function in SPSS was employed. Hierarchical Clustering was used to judge the number of clusters and the clustering quality was checked through two step cluster and finally K-means clustering was done for creating the different groups. Additionally, discriminant analysis was used to evaluate the ability of the variables to predict the classification of respondents into clusters. To ensure the results' accuracy, canonical discriminant analysis was conducted for data verification (Carvalho et al., 2015).

RESULTS

Hierarchical cluster analysis was used to examine whether the 16 adaptation strategies enabled effective farmer segmentation. From the dendrogram, 4 clusters were estimated, which was further validated through Two-step clustering method for the optimal number of clusters by evaluating the Silhouette measure of Cohesion and separation (Figure 1). A value 0.5 with four clusters showed a fair clustering. The value decreased on addition or deletion of a cluster; hence, four clusters were considered appropriate. Further K-means clustering based on centroid method was used for final segmentation. The four identified clusters and the number of farmers in each cluster are presented in Table 1. Cluster 4 had the highest representation with 41 members, followed by Cluster 1 with 31,

Table 1. Number of cases in each cluster

Cluster Number	No. of respondents
1	31
2	18
3	10
4	41

**Figure 1.** Silhouette measure for optimal number of clusters**Figure 2.** Relative importance of predictors in clustering

Cluster 2 with 18, and Cluster 3 with 10 members. The distribution highlights variability in group sizes, indicating diverse adaptation patterns among respondents. The relative importance of various predictors in determining clusters in a two-step cluster model is illustrated in Figure 2. Zero tillage in wheat is the most influential predictor, followed by the use of combined harvesters and crop diversification, indicating their significant role in defining cluster groupings. Water harvesting structures and Direct Seeded Rice (DSR) for climate adaptation also have moderate importance, emphasizing their relevance in distinguishing groups. Predictors like System of Rice Intensification (SRI) and micro-irrigation are the least important, suggesting they have minimal impact on cluster formation. Overall, the model prioritizes practices that focus on sustainable land use and mechanization.

The K-means clustering analysis grouped respondents into four distinct clusters based on the importance they assigned to various adaptation strategies, reflecting unique patterns and preferences (Table 2). Cluster 1 (Mean: 1.77) demonstrated a notable

Table 2. Mean values of the adaptation strategies in different clusters

Adaptation Strategies	Cluster			
	1	2	3	4
Change planting date/periods	1.98	1.39	1.63	1.83
Changes of varieties	2.00	1.72	1.70	1.95
Changes of planting dates	2.00	1.79	1.80	1.83
Raise-bed planter	1.89	2.00	1.80	1.95
Zero tillage in Wheat	1.74	1.00	2.00	1.10
Crop diversification	1.32	1.61	2.00	1.95
Mulching practices	1.71	1.29	1.16	1.89
Laser leveller	1.32	1.55	1.33	1.20
Practising crop rotations	1.83	1.61	1.70	1.80
Water Harvesting Structure	1.48	1.89	2.00	1.78
Micro irrigation	1.81	1.78	1.98	1.55
DSR for climate adaptation	1.93	1.33	1.00	1.69
SRI in rice for enhanced production	1.78	1.00	1.27	1.44
IPM practices	1.74	1.46	1.40	2.00
Bio fertilizers	1.66	1.50	1.80	1.81
Combined harvester	1.94	2.00	1.00	1.34
Two Step Cluster Number	4	2	6	1
Cluster Mean	1.77	1.54	1.60	1.69

emphasis on Changes of planting dates, Changes of varieties, Practising crop rotations, Direct Seeded Rice and Systematic Rice Intensification. This indicates an adoption of crop and agronomic practices. Respondents in Cluster 2 (Mean: 1.54) prioritized raised-bed planting, laser leveller and combined harvester, highlighting a strong preference for Mechanization and Technology integration. Cluster 3 (Mean: 1.60) placed the greatest emphasis on Soil and water management practices, such as Zero tillage, Crop diversification, Water Harvesting Structure and Micro irrigation showcasing their importance in enhancing resilience. Members of Cluster 4 (Mean: 1.69) showed a sustainable and eco-friendly practices, with high importance placed on Mulching IPM practices, and Bio-fertilizers. This group reflects a preference for strategies that integrate sustainability and innovation.

The results of one-way ANOVA reveal variations in socio-personal variables across the four clusters, highlighting significant differences for a few variables while most remain statistically non-significant (Table 3). A significant F-value (3.281) suggests that landholding size varies notably among clusters, with Cluster 2 having the largest average landholding (1.648 acres) and Cluster 3 the smallest (0.779 acres). A significant F-value (2.967) implies that access to market information differs across clusters, with Cluster 1 having the highest mean (1.58) and Clusters 2 and 3 the lowest (1.22 and 1.20, respectively). A substantial difference is observed in annual income ($F = 5.204^*$), where Cluster 3 has the highest average income (1.92), while Clusters 1 and 2 report lower incomes (1.42 and 1.39, respectively). The variables like age, education, family size, number of earners in the family, access to training, and market distance have non-significant F-values ($p > 0.05$). This indicates that there are no substantial differences in these characteristics across the clusters.

To ensure accurate clustering in this study, canonical discriminant analysis was performed. The verification was carried out on 4 clusters and 16 variables which were the adaptation strategies. Discriminant analysis is primarily used to predict group

Table 3. Socio-personal characteristics of Cluster-Based on Mean and Standard Deviation

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	F value (ANOVA)
Age (years)	31.61(3.25)	33.33(7.62)	38.20(11.73)	34.63(10.65)	1.69 ^{ns}
Education (years)	2.55(0.96)	3.11(1.41)	2.60(0.70)	2.59(0.92)	1.38 ^{ns}
Family size (No. of members)	8.26(4.12)	9.83(4.84)	9.90(3.48)	9.29(4.55)	0.69 ^{ns}
No. of people earning in the family (Nos.)	1.65(1.33)	2.56(1.85)	2.10(0.74)	2.20(1.60)	1.53 ^{ns}
Land holding size (acres)	1.10(0.95)	1.65(0.86)	0.78(0.73)	1.31(0.98)	3.28*
Access to Training (1=No, 2=Yes)	1.26(0.45)	1.17(0.38)	1.40(0.52)	1.22(0.42)	0.68 ^{ns}
Market distance (kms)	8.23(3.78)	9.17(3.09)	8.50(2.42)	8.39(2.88)	0.36 ^{ns}
Market Information (1=No, 2=Yes)	1.58(0.50)	1.22(0.43)	1.20(0.42)	1.37(0.49)	2.97*
Annual income (Rs. lakh)	1.42(0.53)	1.39(0.56)	1.92(0.78)	1.57(0.58)	5.20*

Note: *significant at p-value <0.05; ^{ns}Not significant

membership among two or more mutually exclusive categories (Backhaus et al., 2023). Three discriminant canonical functions were identified in the canonical discriminant analysis (Table 4). The results in Table 4 show the effectiveness of these functions in distinguishing between groups. Function F1, with eigenvalues greater than 1, account for 57.5 per cent of the total variance, while the remaining functions contribute only a small percentage to explaining the variance in the analysis. An eigenvalue reflects the proportion of variance explained (the ratio of between-groups sums of squares to within-groups sums of squares). A larger eigenvalue (>1) indicates a stronger function, and in this case, the values are strong. The analysis showed that three discriminant functions had a canonical correlation of 0.744, 0.564 and 0.556 respectively. The canonical correlation, measures the relationship between discriminant scores and the levels of the dependent variable, was high for the function F1 0.744 (with 1.00 being perfect), indicating that the function discriminates very effectively.

Wilks' Lambda is the ratio of within-group sums of squares to the total sums of squares, representing the proportion of variance in the discriminant scores that is not explained by the differences between groups. A Wilks' Lambda value of 1.00 suggests that the group means are equal, meaning all the variance is explained by factors other than the differences between means. A smaller Lambda value indicates that the within-group variability is small in comparison to the total variability, suggesting significant differences between group means (Harlow & Duerr, 2013). As represented in

Table 5, Wilks' Lambda in three tests of functions were significant at p<0.01 with values of 0.211, 0.471, and 0.690 respectively which is very low, indicating that the group means differ significantly.

DISCUSSION

Four different farmer groups were identified by the K-means cluster analysis according to how they prioritised adaptation strategies. This underscores the necessity of customised agricultural and extension interventions to improve climate change adaptation. The crop and agronomic techniques that were highlighted in Cluster 1, which had the highest Mean score (1.77), including crop rotation, Direct Seeded Rice (DSR), System of Rice Intensification (SRI), modifying planting dates, and adopting enhanced crop types. The emphasis on improving crop management to deal with climatic unpredictability is seen in these tactics. For this cluster, promoting climate-resilient crop varieties, optimizing planting schedules using weather forecasts, and enhancing training on DSR and SRI techniques are critical agricultural strategies. Extension activities could include field demonstrations, mobile advisory services, and farmer-to-farmer learning networks to facilitate wider adoption (Bakhsh & Feil, 2021). Cluster 2 (Mean: 1.54) demonstrated a strong preference for mechanization and technology integration, including raised-bed planting, laser levelling, and combined harvesters. These farmers prioritize efficiency and productivity gains through technology. Agricultural strategies for this group should focus on facilitating access to mechanized tools through subsidies or cooperative models and promoting precision agriculture technologies. Extension approaches, such as custom hiring centres, field demonstrations, and collaborations with agricultural technology providers, can further enhance technology adoption. Cluster 3 (Mean: 1.60) highlighted the importance of soil and water management practices, including zero tillage, crop diversification, water harvesting structures, and micro-irrigation systems. These strategies reflect a focus on resource conservation to build resilience. Agricultural interventions should prioritize conservation agriculture techniques, diversified cropping systems, and the establishment of community-managed water harvesting structures. Extension efforts could involve capacity-building workshops, subsidies for micro-irrigation systems, and community-based water management models to improve the adoption of these practices (Kumar et al., 2020). Cluster 4 (mean: 1.69) showed a preference for sustainable and eco-friendly practices, emphasizing mulching, Integrated Pest

Table 4. Eigen value of Canonical Discriminant Analysis

Function	Eigen value	% of Variance	Cumulative %	Canonical Correlation
F1	1.236 ^a	57.5	57.5	0.744
F2	.465 ^a	21.6	79.1	0.564
F3	.448 ^a	20.9	100.0	0.556

a. First 3 canonical discriminant functions were used in the analysis.

Table 5. Wilks' Lambda value of Canonical Discriminant Analysis

Test of Function(s)	Wilks' Lambda			
	Wilks' Lambda	Chi-square	df	Sig.
1 through 3	0.211	138.600	48	0.000
2 through 3	0.471	66.973	30	0.000
3	0.690	32.964	14	0.003

Management (IPM), and bio-fertilizers. This cluster aligns with a sustainability-focused approach to adaptation. Agricultural strategies should promote bio-fertilizers, bio-pesticides, and mulching to enhance soil health and reduce chemical dependency. Extension strategies could include demonstration plots, farmer schools, and improved access to certified bio-inputs. Resource allocation becomes more efficient, prioritizing areas with vulnerable groups for investments in climate-resilient infrastructure (LaFavor, 2022). These findings underscore the heterogeneity in farmers' adaptation preferences, influenced by their agro-ecological and socio-economic contexts. By aligning agricultural and extension strategies with the specific needs and priorities of each cluster, policymakers and practitioners can foster the adoption of climate-smart practices, enhancing resilience and sustainability in farming systems.

CONCLUSION

Policymakers should ensure access to climate-resilient seeds, improved crop varieties, and water-efficient technologies, alongside subsidies for practices like zero tillage, crop diversification, and micro-irrigation. Extension services should offer tailored strategies for different farmer groups, focusing on women's specific vulnerabilities related to land tenure and access to resources. Training programs on sustainable practices, including pest management and water harvesting, should emphasize women-centered approaches, such as self-help groups and farmer field schools. Research should focus on affordable, labor-saving technologies for women, like portable water systems and lightweight mechanization. The private sector can support this by providing affordable bio-inputs, machinery, and financing for women's cooperatives. NGOs and civil society should advocate for resource equity and capacity-building initiatives. These efforts, if well-coordinated, will empower women and enhance agricultural resilience to climate change.

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Knowledge Gap and Path Analysis of Adoption of Makhana (*Euryale Ferox Salisb*) Growers in Bihar

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HIGHLIGHTS

- It was characteristic to note that variables landholding size, annual income, income from makhana and training exposure had positive and highly significant association with technology adoption and knowledge level of farmers.
- Farmers had relatively low knowledge, and adoption level with respect to the improved makhana cultivation technology.
- Based on the noticeable gap in the adoption of improved technology, the study emphasizes on developing and implementing innovative and appropriate location specific technologies tailored to the need of makhana growers.

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Informed consent of the participants

ABSTRACT

This study examined the knowledge gap and adoption of the improved makhana cultivation technology in Bihar. The research utilized a descriptive research design and focused on four districts viz. Purnia, Katihar, Darbhanga, and Madhubani. During 2022–24, eight villages were purposively selected from these blocks which included Pipra and Birpur from Purnea block, Mirzapur and Lachhampur from Barari block, Ballupur and Kishunpur from Bhadurpur block, and Chanuraganj and Simra from Jhanjharpur block. The study included 120 sample, with fifteen makhana growing farmers randomly chosen from each of the eight villages. The findings revealed that plant protection component (disease and pest control) had the highest mean knowledge gap (61.88%), with a relatively low knowledge index of 24.10, and adoption index of 19.33. Further technology adoption and knowledge level of farmers had positive and significant association with landholding size, annual income, income from makhana and training exposure. Improvement in information dissemination on latest technical knowhow via focused campaigns and farmer engagement activities through need based trainings is crucial for increasing the adoption of improved makhana cultivation technology among the farmers for enhanced productivity and profitability.

INTRODUCTION

Makhana (*Euryale ferox* Salisb), is popularly known as fox nuts, in India and other parts of Asia. It is obtained from the seeds of the plant, which is native to India and other parts of Asia. Makhana is known as the global wonder nut for being nutritious and combating many diseases. It has been used in traditional Ayurvedic medicine for centuries and is known for its high nutritional value and health benefits. In recent years, Makhana has gained popularity as a health food due to its low calorie and fat

content, high fibre content, and various other nutritional benefits. It is also grown in some other parts of Asia, including China, Japan, and Korea. The global Makhana market is expected to grow by USD 72.5 million, with a CAGR of almost 7% during 2019–2023. (APEDA)

Bihar is the main producer of Makhana in the country and produces 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 production of Makhana seeds is around 1,20,000 MT, which after processing becomes 40,000 MT of makhana pop. 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 (Anonymous, 2022).

In Bihar, the area under makhana cultivation is about 13,000 hectares, contributing to 85 per cent of India's total production. Major producing districts include Darbhanga, Sitamarhi, Madhubani, Saharsa, Supaul, Araria, Kishanganj, Purnia, and Katihar. Darbhanga and Madhubani districts alone account for approximately 80 per cent of the processed Makhana production (Ahmad, 2020).

The adoption of improved technology for makhana cultivation in Bihar is low due to several factors. Primary among these is the small size and fragmentation of land holdings, which pose significant constraints to the adoption of modern horticultural technology (Singh et al., 2015). Additionally, the limited access to water resources, quality inputs, and credit for sub-marginal and marginal farmers further restricts the use of advanced technologies. Despite the presence of agricultural extension institutions like ATMA (Agricultural Technology Management Agency) and KVK (Krishi Vigyan Kendra), their outreach is limited, and they face challenges such as inadequate staff and infrequent supervision (Singh et al., 2015). The main objective of study was to find the knowledge gap and extent of adoption in improved makhana cultivation practices.

METHODOLOGY

The state of Bihar consists of a total of 38 districts. The present study was conducted in Bihar across four leading districts of makhana cultivation during 2022-24. Purnea, Katihar, Darbhanga, and Madhubani districts were purposively selected for the study because they are important districts for Makhana production. According to the Government of Bihar (2022), Purnea has a total area of 5549 hectares dedicated to makhana cultivation, resulting in a production of 11652.9 tons. In comparison, Katihar, Darbhanga and Madhubani has an area of 6143, 3534, 3467 hectares respectively under makhana cultivation, which yields a production of 12900.3, 7421.4, 7280.7 tons respectively. The study specifically examined the regions of Purnea East in Purnia, Barari in Katihar, Bahadurpur in Darbhanga, and Jhanjharpur in Madhubani. Two villages with higher productivity in makhana farming were deliberately chosen from each block, resulting in selection of eight villages. A thorough compilation of all households in these villages engaged in makhana cultivation was carried out, and 120 makhana growers were selected through random sampling. Primary data were acquired with help of a pre-tested structured interview schedule developed specifically for the study and direct observation methods. Secondary data were obtained from the official records of government, and gram panchayats. The interview schedule included 11 components and 24 issues with regards to improved makhana farming techniques which were used to evaluate the participants' knowledge. The scoring system for knowledge was as follows: full knowledge (2 points), medium knowledge (1 point) and no knowledge (0 point). The adoption level was also assessed for 11 aspects and 24 issues, using a scoring system of fully adopted (2 points), partially adopted (1 point), and not adopted (0 point).

The highest attainable score for both knowledge and adoption was 48. A knowledge gap and adoption index was developed.

$$\text{Knowledge gap index} = \frac{\text{Total achievable score} - \text{Total score achieved}}{\text{Total achievable score}} \times 100$$

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

The respondents were classified into three groups, viz., low, medium and high based on their scores of mean and standard deviation. The study also examined the association between socio-economic status and levels of knowledge and adoption using Pearson correlation analysis. Path analysis, a precursor to and subset of structural equation modeling, was used to discern and assess the effects of a set of variables acting on technology adoption via multiple causal pathways. Data were subjected to path analysis in order to identify the potent variables and mechanism of influencing the adoption of improved makhana cultivation technology.

RESULTS

The data revealed that knowledge gap of makhana growers were manifested in eleven distinct aspects of improved makhana cultivation technology. It was revealed from Table 1 that with respect to plant protection including pest and disease management practices, the mean knowledge gap was 61.88 per cent. Further, the respondents didn't have adequate knowledge regarding soil characteristics with a special focus on appropriate soil types, and 60.84 per cent knowledge gap was observed in this aspect.

The mean knowledge gap on pond construction was found to be 60.14, followed by recommended seed rate and sowing time as 53 per cent. The mean knowledge gap on recommended varieties of makhana viz., Swarna Videhi and Sabour Makhana-1, was found to be 52.09 per cent, followed by 51.67 per cent on seed yield, 43.71 per cent on marketing of makhana products, 42.50 per cent on recommended practice of harvesting, 37.23 per cent in case of weed control and 28.34 per cent on appropriate use and recommended doses of manures and fertilizers.

Farmers were classified according to their overall knowledge and adoption levels with respect to recommended makhana cultivation technology. Table 2 revealed that the mean knowledge index of farmers was 24.10 with a standard deviation of 3.97. Based on the overall knowledge score, 75.00 per cent of the respondents were classified under moderate knowledge level category. The mean adoption index was 19.33 with a standard deviation of 3.26. The study exhibited that 64.16 per cent of respondents had a moderate level of adoption meanwhile 15 per cent of them demonstrated a low level of technology adoption.

Table 3 exhibited the association of selected independent variables with the dependent variables Knowledge and technology adoption of farmers with respect to recommended makhana cultivation technology. It was revealed that the variables viz., family size and experience in makhana cultivation had positive and significant correlation with knowledge level at 5% level of probability whereas, scientific orientation had positive and

Table 1. Knowledge gap of farmers on improved makhana cultivation technology

S. No.	Aspects along with recommended practices of makhana cultivation	Knowledge level			Knowledge Gap (%)
		Full (%)	Partial (%)	No knowledge (%)	
1.	Soil				
	(i) Soil Quality	19.17	80.83	0.00	60.84 ^{II}
	(ii) Type of Soil	0.00	0.00	100.00	
	(iii) Water holding Capacity of Soil	15.84	84.16	0.00	
2.	Pond construction				
	(i) Water capacity of Pond/field	10.83	89.13	0.00	60.14 ^{III}
	(ii) Shape of Pond/field	10.00	90.00	0.00	
	(iii) Slope of Pond/ Field	1.66	15.00	83.33	
3.	Varieties				
	(i) Improved Varieties	5.83	89.16	5.00	52.09
	(ii) Seed Quality	3.33	84.16	12.50	
4.	Sowing				
	(i) Sowing Time	91.66	8.34	0.00	28.34
	(ii) Transplanting time	3.33	88.33	8.33	
5.	Seed rate				
	(i) Recommended seed rate	0.00	83.33	16.66	53.00
6.	Nutrient management				
	(i) Kind of fertilizer	5.83	51.66	42.50	53.47
	(ii) Manure and fertilizer dose	10.00	84.16	5.83	
	(iii) Quantity of manure	16.66	78.33	5.00	
7.	Weed management				
	(i) Types of weeds	90.00	10.00	0.00	37.23
	(ii) Method of weed treatment	8.33	66.66	25.00	
	(iii) Chemicals used	3.34	96.66	0.00	
8.	Disease and pest management				
	(i) Disease and pest name	19.16	80.83	0.00	61.88 ^I
	(ii) Chemicals used	10.00	13.33	76.67	
9.	Harvesting of Makhana				
	(i) Ideal time for harvesting	13.33	85.83	0.00	42.50
	(ii) Method of harvesting	16.66	83.33	0.00	
10.	Yield of Makhana				
	(i) Potential yield	7.50	81.66	10.84	51.67
11.	Marketing of seeds				
	(i) Place to sell makhana seeds	11.67	88.33	0.00	43.71
	(ii) Marketing grade of Makhana pop	17.50	82.50	0.00	

Table 2. Knowledge and adoption level of farmers with respect to recommended makhana cultivation technology

S. No.	Categories	Knowledge			Adoption		
		Percentage	*Mean#	SD	Percentage	*Mean#	SD
1.	Low level (<mean – SD)	10			15		
2.	Medium level (mean – SD to mean + SD)	75	24.10	3.97	64.16	19.33	3.26
3.	High level (>mean + SD)	14.16			20.83		

significant association with technology adoption at 5% level of probability.

It was further revealed that variables viz., Land holding under makhana cultivation, annual income, income from makhana and training exposure had positive and highly significant association with knowledge level as well as technology adoption at 1% level of probability.

Path analysis was used to discern and assess the effects of a set of variables acting on technology adoption via multiple causal pathways. Table 4 revealed that the direct and indirect effects of

each variable on adoption level of recommended makhana cultivation technology. It was found that income from makhana exerted maximum direct effect (-3.833) in negative direction. However, size of land under makhana cultivation exerted maximum direct effect (3.107) on technology adoption followed by annual income (1.238) in positive direction.

It was further revealed that the variable Annual income exerted maximum indirect effect (-3.82) in negative direction on adoption level and it was routed through income from makhana, size of land holding under makhana and knowledge.

Table 3. Relationship between independent variables and the dependent variables

Independent Variables	Knowledge 'r'	Adoption 'r'
Age	0.078	0.077
Gender	-0.123	-0.050
Marital status	-0.076	-0.076
Family size	0.217*	0.115
Education	-0.019	0.005
Experience	0.228*	0.055
Size of land holding under Makhana	0.440**	0.506**
Annual income	0.424**	0.495**
Income from Makhana	0.404**	0.484**
Attitude	0.062	0.105
Scientific Orientation	0.055	0.375**
Training exposure	0.370**	0.260**

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

DISCUSSION

It was evident that makhana growers had the highest gap in mean knowledge with respect to disease and pest management practices. It was characteristic to note the prevalence of pests like singhara beetle, aphids, caseworms, fruit borer, root borer and fruit rot and some fungal diseases like leaf blight as new occurrences in makhana but most of the farmers were ignorant about their control methods. This result was in consonance with the findings of Toure et al., (2023); Roy & Bandyopadhyay (2019), which indicated that due to lack of knowledge about management practices, extensive extension works were needed to raise awareness of disease and pests of crops while seeking effective control strategies. The finding was further supported by Bhagat et al., (2002) & Assgba et al., (2015) who reported the presence of various diseases of which the most important were viruses, and leaf and petiole yellowing. However, findings of Kumar & Jahanara (2021) emphasized that farmer's knowledge related to disease and pest control increases by imparting trainings and other capacity building programmes. The knowledge gap exceeded 50 per cent in other important technical domains as well like suitable soil with adequate water holding capacity, modern methods of pond preparation, recommended seed rate, sowing time

as well as recommended varieties. These findings are supported by several studies highlighting significant gaps in farmers' knowledge and adoption of best practices in these areas. Gap in Knowledge and technology adoption can be abridged by capacity building of farmers and associated stakeholders, public-private partnerships, and actors within the value chain. There should be a provision of technical guidance, establishment of market connections, and training programs. The interventions can be reinforced through on-farm demonstrations and use of information and communication technology (ICT) tools.

Liu et al., (2022) reported that participation in technical training can significantly enhance the probability of the adoption of improved farm technologies. The study revealed that most of the farmers had moderate level of knowledge with respect to recommended technology of makhana cultivation. Similar findings were reported by Kumar & Kumar (2021); Manoj et al., (2024); Moulasab & Sudhakara (2017). Lairenjam & Bose (2024) reported that farmers have limited formal education, which can affect their capacity to understand and implement advanced agricultural technologies. This educational gap contributes to a moderate level of knowledge regarding recommended practices. Farmers also often lack regular interaction with agricultural extension services, which are crucial for disseminating updated cultivation practices. This limited access hindered their ability to acquire comprehensive knowledge about recommended technologies of makhana. The relationship between land holding size and adoption of recommended makhana cultivation technology was positively correlated, suggesting that larger land holdings may facilitate the adoption of makhana cultivation practices. This could be due to the fact that larger landowners have more resources and space to diversify their crops and experiment with makhana cultivation, which is a cash crop providing significant economic benefits (Ahmad, 2020; Kumar et al., 2021).

Higher income levels were linked to greater knowledge of recommended cultivation practices, indicating that wealthier farmers might have better access to information about new technologies. Training exposure had positive and significant association with knowledge and technology adoption of farmers. Participation in training programs enhances farmers' knowledge and adoption of

Table 4. Path analysis of independent variables with adoption of recommended makhana cultivation technology

Variables	Direct effect	Indirect effect	Substantial indirect effect through single variables		
			I	II	III
Age (X1)	-0.1311	-1.4107	-0.098(X6)	-0.049(X7)	-0.047(X8)
Gender (X2)	-0.0012	0.1165	0.009(X5)	0.008(X1)	0.007(X6)
Marital status (X3)	-0.0221	-0.1886	-0.008(X6)	-0.006(X1)	-0.004(X5)
Family size (X4)	-0.0711	-0.7780	-0.022(X1)	-0.150(X7)	-0.14(X6)
Education (X5)	-0.0610	0.5433	-0.017(X1)	0.0116(6)	0.011(X3)
Experience (X6)	0.0222	-0.8819	0.016(X1)	0.008(X3)	0.005(X7)
Size of land holding under Makhana (X7)	3.1078	-3.8187	3.095(X9)	3.091(X8)	1.362(X13)
Annual income (X8)	1.2389	-3.8236	1.23(X9)	1.24(X7)	0.521(X13)
Income from Makhana (X9)	-3.8337	3.0957	-3.82(X8)	-3.817(X7)	-1.613(X13)
Attitude level (X10)	-0.0547	-0.3633	-0.020(X11)	-0.011(X6)	-0.007(X1)
Scientific orientation (X11)	0.3443	-0.3365	0.0131(X10)	0.131(X6)	-0.570(X3)
Training exposure (X12)	-0.0991	-1.3144	-0.035(X7)	-0.034(X8)	-0.032(X13)
Knowledge (X13)	0.1406	-1.6134	0.061(X7)	0.059(X8)	0.051(X9)

recommended practices (Lairenjam & Bose, 2024). High negative direct effect of income from makhana on the adoption level indicated that as income increased, the likelihood of adopting new practices significantly decreased. This relationship might be explained by various factors. Initially, farmers with a high income from makhana believed to be confident in their existing practices and perceived no necessity for adopting new technologies, considering such adoption not rewarding or possibly risky. Furthermore, successful farmers might have thoroughly assessed the cost-benefit ratio of adoption and determined that the marginal benefits exceeded the corresponding costs in terms of time, resources, or effort as reported by Ahamad (2020); Ali & Karim (2009). High-income farmers also appeared to lack the urgency to improve productivity further, as they were already earning well through traditional methods. This sense of complacency contrasted with low-income farmers, who viewed adoption as essential for improving their livelihoods. Furthermore, wealthier farmers might have resisted change due to cultural or social preferences, fearing disruptions to their successful traditional practices. They might have diversified into other income sources or prioritized investments outside agriculture rather than adopting innovations in makhana farming.

Size of land under makhana cultivation exerted maximum direct effect on technology adoption in positive direction. Larger land sizes positively affect farmers' technology adoption behavior, suggesting that farmers with more extensive landholdings are more inclined to implement integrated land management technologies as reported by Haile et al., (2024).

It was found that a significant proportion of respondents exhibited a medium level of adoption of recommended makhana cultivation technology. This could imply that medium-level adoption across different agricultural sectors may be attributed to factors such as limited educational levels, economic motivations, and access to technology and information as reported by Nain & Bhagat (2005); Nain et al., (2013); Ghaghas et al., (2017); Mariyappan et al., (2018); Melkeri (2018); Sathisha et al., (2018); Antim et al., (2022); Wasu et al., (2022); Khawale & Chinchmalatpure (2023); Kumari & Mazhar (2023); Sangeetha et al., (2023); Pongener & Jha (2024); Thangjam et al., (2024). Many farmers continue to depend on traditional methods passed down through generations. This reliance can impede the adoption of new technologies, as traditional practices may not align with current recommendations (Kumar et al., 2020).

CONCLUSION

Knowledge and adoption of recommended technologies in makhana cultivation play a pivotal role in enhancing both the productivity and profitability of farmers. Empowering farmers with adequate knowledge through targeted capacity-building programs, need based training programmes, is essential for bridging the existing knowledge gap. Encouraging the adoption of innovative and scientifically backed practices, such as improved seed varieties, modern pond preparation techniques, and efficient post-harvest management, will significantly boost yields and economic returns. A comprehensive strategy that integrates farmer-centric extension services, market linkages, and support for smallholder farmers is crucial to achieving sustainable growth in makhana cultivation. By

focusing on these aspects, policymakers, researchers, and agricultural stakeholders can ensure that farmers maximize their potential and contribute to the overall development of the makhana industry.

Author contributions

Conceptualization of research (KKJ, KS); Designing of the experiments (KKJ, KS); Contribution of experimental materials (KKJ, KS); Execution of field survey and data collection (KS); Analysis of data and interpretation (KS); Preparation of manuscript (KKJ, KS).

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Farmers' Preference for IARI Wheat Varieties in North Western Plain Zone (NWPZ) and Central Zone (CZ) of India

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HIGHLIGHTS

- Higher grain yield was selected as the most preferred attribute among farmers followed by higher straw yield and bold grain size.
- The eleventh combination was the most preferred in the study with utility scores of 19.079 for NWPZ farmers, and 16.617 for CZ farmers.
- Plant height was the least significant factor having 3.925 per cent contribution in NWPZ and 3.507 per cent in CZ.

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ABSTRACT

This research work was conducted in 2023 to identify preferred traits of *Triticum aestivum* and *Triticum durum* wheat among farmers in North-Western Plain Zone (NWPZ) and Central Zone (CZ) of India, respectively. The method of sampling used for choosing 120 farmers was multi-stage random sampling, of which 60 farmers were from Aligarh, Uttar Pradesh, and 60 farmers were from Dewas, Madhya Pradesh. SPSS was used to perform quantitative conjoint analysis of the preferences for plant height, crop duration, irrigation requirement, pest attack, grain yield, grain size, and straw yield. From observations taken during the interviews, farmers preferred early maturity, species or hybrids with high grain and straw yield, large grain size, high market price, low water usage through irrigation, and disease or pest attack rating. Grain yield and straw yield, grain size, and market rate had a very high influence on preference, while plant height had the least influence. These insights can inform future wheat breeding programs aligned with preferences by farmers to improve food production in the NWPZ and CZ regions. Understand what these preferences are and formulate varieties that will meet the requirements for better food production.

INTRODUCTION

Cereals are essential for meeting the world's expanding population's food needs, especially in developing countries (Nikos & Jelle, 2012). The Levant originated cereal is among the most important global food crops, following rice and maize (Acevedo et al., 2018), contributing 20 per cent of the daily calorie and protein intake globally (Shiferaw et al., 2013). India is the second largest producer of wheat in the world, producing 110.5 million tonnes in 2021-22 (Goyal et al., 2024). However, the situation in the past was not at all like that; from 1947 to 1960, India had to import wheat (Nelson et al., 2019), but with the help of the Green

Revolution in the sixties, it had achieved surplus production of wheat (Sharma et al., 2015). Amidst the varied agro-ecological zones of India, North Western Plain Zone and Central Zone are the most wheat-producing parts of the nation (Gupta et al., 2023). Punjab, Haryana, western Uttar Pradesh, and Rajasthan make up the North West Plain Zone (NWPZ) (Singh et al., 2014), which is the most productive wheat belt in India and accounts for 70–75 per cent of the country's annual wheat production (Singh et al., 2019). Whereas the Central Zone consists of Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan, and Jhansi division of Uttar Pradesh (Prasad et al., 2024). CZ is prominent for its *Triticum durum* variety of wheat (Saini et al., 2023), whereas

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NWPZ is famous for its *Triticum aestivum* variety, which is used for Roti/Chapatti (Mohan et al., 2023). Despite the prominence of these regions in wheat production, there are still various bottlenecks associated with wheat production, e.g., there is a variation in wheat production in the NWPZ region, with average yields of 4.2 t ha⁻¹ in Punjab, 3.9 t ha⁻¹ in Haryana, and 2.7 t ha⁻¹ in Uttar Pradesh, despite guaranteed irrigation and other management aids (Saikia et al., 2011). Along with low fertility of soil and weather aberrations, overuse of groundwater resources, decrease in the response to applied fertilizers, emergence of micronutrient deficiencies and herbicide-resistant weeds, and growing pressure from pests and diseases (Bhatt et al., 2016; Bhatt et al., 2021). So, preferring a good quality of seed is the most essential part for the cultivation of wheat cultivation since seed quality solely can contribute 15-20 per cent to the overall production of crops (Jethi et al., 2022). Preference is defined as evaluative judgment, involving liking or disliking an object commonly used in social sciences and cognitive sciences (Scherer, 2005). Varietal characteristics such as maximum yield, pest and disease resistance, grain quality, number of irrigations required, etc., influence a farmer's decision on accepting or rejecting a particular variety of wheat. This paper aims to capture the preference of varietal traits of the *Triticum aestivum* and *Triticum durum* among the farmers of NWPZ and CZ, respectively, using conjoint analysis. Understanding the farmer's preference regarding the varietal traits of wheat is crucial for improving the wheat productivity as well as the economic conditions of the farmers associated with it.

METHODOLOGY

A systematic multi-stage random sampling method was used to conduct the study between 2022 and 2023. It started by targeting Uttar Pradesh as a favourable *Triticum aestivum* production locality, followed by selection of Aligarh district and villages at Bhamraula and Madhola. For the *Triticum durum* variety, Madhya Pradesh was the selected state with emphasis on Dewas district and the villages of Mendki Dhakar and Sarola. A total of 120 farmers across the two zones were sampled, and 60 respondents in each zone were interviewed in person and analysed using conjoint analysis. Upon review of literature and expert/key informant interviews, eight attributes were finally selected. The attributes for *Triticum aestivum* and *Triticum durum* included grain yield and straw yield, classified into three levels: less than 40 q/ha, 40-50 q/ha, and more than 50 q/ha. Grain size was divided into small and bold. Market rate at the same or higher than other non-IARI varieties. Pest incidence was assessed as more or less susceptible. Plant height was classified as tall and dwarf, and irrigation requirements were categorized into 3-4 or 5-6 irrigations. Using SPSS, an orthogonal design with sixteen combinations of eight attribute were generated. The farmers ranked the combinations, from which total scores and utility estimations of each attribute were collected. Finally, additive conjoint model was used to find the most preferred attribute, which expressed as:

$$U = \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon$$

Whereas, U = Product's overall utility, $\beta_1, \beta_2, \beta_n$ = part worth utilities related to each trait. X_1, X_2, \dots, X_n = level of each attributes, ε = error term

RESULTS

Preference in this context operationalized as the farmers' inclination for certain characteristics of the various IARI wheat varieties in terms of grain yield, grain size, market rate, incidence of pests and diseases, crop length, as well as irrigation requirements and straw output.

A conjoint model with eight attributes with various levels as discussed above was developed to identify the preference for attributes for IARI wheat varieties. Afterwards, utility estimate for different levels of attributes calculated using SPSS software, utility estimate indicates degree of preference of a particular level in each attributes, with higher values indicating higher preference and lower values indicating lower preference. The utility estimates of various levels of attributes presented in Table 1.

Table 1. Attributes of wheat varieties favoured mostly in the entire study area

Attributes	Levels	NWPZ Utility estimate	CZ Utility estimate
Grain yield	<40 q/ha	4.425	4.613
	40-50 q/ha	8.851	9.226
	>50 q/ha	13.276	13.838
Grain size	Small	1.264	0.870
	Bold	2.528	1.741
Market rate	Similar to non-IARI varieties	0.340	0.120
	Higher than non-IARI varieties	0.679	0.241
Plant height	Tall	0.042	-1.713
	Dwarf	0.085	-3.426
Pest and disease incidence	More	0.189	0.178
	Less	0.377	0.344
Crop duration	<110 days	-1.111	-0.572
	110-130 days	-2.223	-1.145
	>130 days	-3.334	-1.717
Irrigation number	5-6	0.495	0.199
	3-4	0.991	0.344
Straw yield	<40 q/ha	0.902	1.170
	40-50 q/ha	1.804	2.340
	>50 q/ha	2.707	3.510
Constant		-2.373	-2.514

From Table 1 it can be seen that grain yield's preference in terms of varietal traits is quite similar amongst the farmers of NWPZ and CZ. In NWPZ and CZ, highest grain preference was shown in the grains yielding more than 50 q/ha with utility estimate of 13.276 and 13.838 respectively. Bold grains were preferred to small grains with utility estimate of 2.528 and 1.741 in NWPZ and CZ respectively. Farmers of NWPZ and CZ preferred the varieties with higher market rates with utility estimate of 0.679 and 0.241 respectively. Most farmers of NWPZ preferred dwarf to tall ones in relation to plant height with utility estimate of 0.085 and it is

Table 2. Utility scores for different combinations of characteristics of IARI wheat varieties ranked the in study area

Card no.	Grain yield	Grain size	Market rate	Plant height	Pest & disease incidence	Crop duration	Irrigation number	Straw yield	NWPZ		CZ	
									Total score	Rank	Total score	Rank
1	<40 q/ha	Bold	Similar to non-IARI varieties	Dwarf	More	>130 days	3-4	>50 q/ha	7.931	XII	7.13	IX
2	<40 q/ha	Bold	Similar to non-IARI varieties	Tall	More	<110 days	3-4	40-50 q/ha	9.589	IX	6.906	X
3	40-50 q/ha	Bold	Higher than non-IARI varieties	Tall	Less	110-130 days	3-4	>50 q/ha	13.834	V	12.403	V
4	>50 q/ha	Small	Higher than non-IARI varieties	Tall	More	<110 days	5-6	>50 q/ha	18.369	II	14.838	II
5	<40 q/ha	Small	Similar to non-IARI varieties	Dwarf	Less	<110 days	5-6	>50 q/ha	8.582	X	5.587	XI
6	<40 q/ha	Bold	Higher than non-IARI varieties	Dwarf	Less	<110 days	5-6	<40 q/ha	8.380	XI	4.509	XIV
7	<40 q/ha	Small	Similar to non-IARI varieties	Tall	Less	110-130 days	5-6	40-50 q/ha	6.902	XIV	3.915	XV
8	<40 q/ha	Bold	Higher than non-IARI varieties	Tall	Less	>130 days	5-6	<40 q/ha	6.312	XVI	3.165	XVI
9	40-50 q/ha	Small	Higher than non-IARI varieties	Dwarf	More	>130 days	5-6	40-50 q/ha	10.033	VIII	8.110	VIII
10	40-50 q/ha	Bold	Similar to non-IARI varieties	Tall	More	<110 days	5-6	<40 q/ha	12.614	VI	8.636	VII
11	>50 q/ha	Bold	Higher than non-IARI varieties	Dwarf	Less	<110 days	3-4	40-50 q/ha	19.079	I	16.617	I
12	40-50 q/ha	Small	Similar to non-IARI varieties	Dwarf	Less	<110 days	3-4	<40 q/ha	11.699	VII	9.843	VI
13	<40 q/ha	Small	Higher than non-IARI varieties	Dwarf	More	110-130 days	3-4	<40 q/ha	6.492	XV	4.612	XIII
14	<40 q/ha	Small	Higher than non-IARI varieties	Tall	More	<110 days	3-4	<40 q/ha	7.759	XIII	4.986	XII
15	>50 q/ha	Bold	Similar to non-IARI varieties	Dwarf	More	110-130 days	5-6	<40 q/ha	16.042	III	12.874	IV
16	>50 q/ha	Small	Similar to non-IARI varieties	Tall	Less	>130 days	3-4	<40 q/ha	14.866	IV	13.111	III

vice versa for CZ with utility estimate of -1.713 of tall varieties. In relation to incidence of pest and disease, in both NWPZ and CZ majority of the farmers preferred low incidence of pests and diseases with a utility estimate of 0.377 and 0.344. Furthermore, farmers in both regions also preferred crop durations to be shorter than the longer crop durations with utility estimate of -1.111 and -0.542. They also preferred straw yields where the higher straw yields (>50 q/ha) were preferred to the lower yields (40-50 q/ha). Altogether, the farmers of both regions (NWPZ and CZ) preferred the varieties which required 3-4 irrigations compared to 5-6 irrigations, with a utility estimate of 0.991 and 0.344. Furthermore, utility ratings were used to construct rankings for the different combinations. The combination with the highest ratings represents the farmers' desire at the highest level, and the combination with the lowest values represents their preference at the lowest level. Using this technique, researchers could ascertain, based on farmers' choices, which set of factors they preferred. The rankings offer insightful information about the factors that farmers consider most crucial when choosing crops. The overall utility scores for various combination of IARI wheat varieties in NWPZ and CZ are presented in Table 2.

Farmers in both regions, NWPZ and CZ had quite similar preferences; the eleventh combination was the most favoured combination, followed by fourth and fifteenth combination was selected equally by farmers in both regions with a utility estimate of 19.079, 18.369 and 16.042 in North West Plain Zone. In Central Zone, eleventh combination was most favoured combination among farmers followed by fourth and sixteenth combination with an overall utility score of 16.617, 14.838 and 13.111 respectively. Finally, 8th combination was the least favoured combination among farmers of North West Plain Zone and Central Zone with an overall utility score of 6.312 and 3.165 in NWPZ and CZ respectively.

Furthermore, among the eight attributes selected for inspecting preference of farmers on varietal traits, average important percentage scores for different attributes representing percentage rankings of preferred attributes taken into account. Higher the percentage scores represent greater level of preference among the sample and vice versa. The relative importance values of different attributes of IARI wheat varieties in both regions of NWPZ and CZ are presented in the Table 3.

In the above Table 3, grain yield got the highest importance with a relative importance percentage of 49.369 per cent and 50.024 per cent respectively in NWPZ and CZ, followed by straw yield,

Table 3. Relative importance of various attributes of wheat varieties in the study area

Attributes	Relative importance (%)	
	NWPZ	CZ
Grain yield	49.369	50.024
Straw yield	12.412	12.70
Grain size	10.089	9.141
Market rate	9.255	8.597
Irrigation number	4.988	6.491
Crop duration	4.706	5.202
Pest and disease incidence	5.247	3.528
Plant height	3.925	3.507

grain size and market rate in both North Western Plain Zone and Central Zone of India, whereas plant height got the least importance among the attributes with relative importance percentage of 3.925 and 3.507 in NWPZ and CZ respectively.

Correlation between observed and estimated frequencies in North Western Plain Zone (NWPZ) and Central Zone (CZ) presented in the Table 4.

Table 4. Correlation between observed and estimated preferences for wheat in study area

	Correlation coefficient		Significance	
	NWPZ	CZ	NWPZ	CZ
Pearson's R	0.976	0.974	0.001	0.001
Kendall's tau	0.917	0.883	0.001	0.001

Data in the Table 4 shows the strong degree of correlation between observed and estimated preferences of IARI wheat varieties in both regions of NWPZ and CZ, which point towards accurate response by the respondents.

DISCUSSION

The study showed that there is a strong favour for quality, like higher grain and straw yield, bold seed, small plant height, and less pest and disease incidence, and a lesser irrigation number among the respondents of the study area. The findings are similar to Semahegn et al., (2021), who found that farmers in the study regions ranked high grain output as their most desired attribute, followed by early maturity, disease resistance, and stress adaptation (tolerance to heat and drought). Teferi et al., (2020), in their study on varietal preference of wheat, found that when considering the relative importance of the features, farmers are ready to spend ten times as much on a variety that is resistant to rust. This is quite evident in this research too, where farmers of NWPZ found resistance to pest and disease as a trait in wheat variety relatively more important with a score of 5.247 per cent (Table 3). However, farmers of CZ find it less important with a score of 3.528 (Table 3). Bold grains were one of the most sought-after characters among the wheat farmers of NWPZ and CZ, with utility scores of 2.528 and 1.1741, respectively (Table 1), and relative importance of 10.089 percent and 9.141 per cent in NWPZ and CZ, respectively (Table 4), primarily because it can generate more revenue in the market. Results of which are aligned with the research of Krishna et al., (2022), where they found that the colour of the mature grains (light-coloured and bold) and the quality of the wheat variety specifically suited for chapattis (taste, puffiness) were the traits favoured by the majority of the respondents. In their study on farmers' preferences for improved wheat varieties, Bhatt et al., (2020) discovered that farmers' preferences for a variety were influenced by other significant characteristics in addition to yield. Stem thickness, pest tolerance, and flour quality. Pandit et al., (2011), in their study on wheat varieties, found that farmers preferred those varieties that have an overall advantage over the one that has only a higher yield. These results are analogous with the current study where farmers of both NWPZ and CZ have chosen the combination number 11 (Table 2), having grain yield

more than 50 q/ha, bold seeds, price higher than non-IARI varieties, dwarf plant height, less pest and disease incidence, crop duration less than 110 days, need 3-4 irrigations, and straw yield less than less than 40 q/ha; this result shows farmers tend to choose a combination of traits that have an overall benefit.

CONCLUSION

The purpose of this research is to determine the extent of farmers' managerial preferences for IARI wheat cultivars that are cultivated in the Central and North Western Plain Zones of India. Yield was listed as a very important grain trait; in particular, grain yield above 50 quintals per hectare was preferred. Farmers preferred traits included straw yield of 40 to 50 quintals per ha, bold grains, low plant height, low pest pressure rates, market prices above non-IARI varieties, number of irrigations (3-4), and days to maturity (less than 110). This study shows that it is not beyond the realm of possibility to conduct quality seed research that would fit farmer's needs. However, in some cases, optimism of expectations for traits does not manifest itself in positive outcomes. More future studies should be conducted exploring other crops of interest, strengthening the R-E-F linkages, and ensuring that investigated problems are relevant to farmers' priorities.

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Evaluating the Adoption Levels of IPM among Vegetable Cultivators in Eastern Uttar Pradesh

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HIGHLIGHTS

- 49.16 per cent of vegetable growers exhibited medium adoption, with cultural practices like deep ploughing better adopted than biological or mechanical methods due to labor and knowledge constraints.
- Education, landholding size, and extension contact positively impacted IPM adoption, while social participation and scientific orientation had minimal or negative correlations.
- Low adoption of biological and mechanical methods stems from labor intensity, technical challenges, and farmers' preference for chemical controls, highlighting the need for targeted training and resource support.

ARTICLE INFO

Keywords: Vegetable growers, Integrated Pest management, Adoption level, Sustainable Agriculture, Socio-economic factors.

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ABSTRACT

This study examines the adoption of Integrated Pest Management (IPM) practices among vegetable growers in Mau District, Uttar Pradesh, during 2022-2023. Two significant blocks, Ratanpura and Kopaganj, were purposively selected, with data collected from 120 respondents across 12 randomly chosen villages. Respondents were categorized into marginal, small, medium, and large growers. Using a semi-structured interview schedule, adoption levels were measured, revealing that 49.16 per cent of respondents had a medium level of IPM adoption. Correlation analysis demonstrated that socio-economic factors, including age, education, landholding, income, risk orientation, and extension contact, had a significant positive relationship with IPM adoption. Conversely, social participation and scientific orientation exhibited significant negative correlations with adoption levels, while marital status and family type had a non-significant positive association. These findings underscore the necessity for policy interventions aimed at overcoming barriers to IPM adoption. Enhancing the accessibility and quality of extension services, implementing targeted training programs to improve awareness, and providing financial incentives and infrastructural support. Promoting sustainable pest management practices not only improves agricultural productivity but also strengthens ecological balance, contributing to long-term agricultural sustainability. These results suggest that increased socio-economic factors are associated with greater IPM adoption among vegetable growers.

INTRODUCTION

Horticultural crops include a wide variety of fruits, vegetables, flowers, and plantation crops, with vegetable farming being particularly attractive due to its higher profitability compared to

field crops. Vegetables play a crucial role in crop diversification, employment generation, and enhancing nutritional security, improving farmers' economic conditions. They are rich in vitamins A and C, proteins, and fibers, contributing to human health. India

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is the second-largest producer of vegetables globally, contributing about 14 per cent of the world's vegetable production (Kumar et al., 2022).

India's total horticultural output is forecasted to reach 355.48 million tonnes in 2022-2023, an increase of 8.3 million tonnes (2.39%) from the previous year. The area under horticultural cultivation expanded by 1.41 per cent, with vegetable production rising from 209.14 million tonnes in 2021-22 to 212.55 million tonnes in 2022-23. India leads the world in the production of onions, ginger, and okra, and ranks second in potatoes, cauliflowers, brinjal, and cabbages (FAO, 2022). Despite India's global market share being near 1%, the acceptance of Indian horticultural produce is increasing, thanks to advancements in cold chain infrastructure and quality assurance. In 2023-24, India exported fruits and vegetables worth Rs. 15,039.27 crores (US \$1,814.58 million), with vegetables contributing Rs. 6,861.05 crores (US \$828.26 million) (apeda.gov.in).

Vegetables have contributed 59-61 per cent to India's horticultural crop production over the past five years. There is a growing focus not just on high yields but on producing better-quality vegetables, as these fetch higher prices. Vegetables are grown in diverse agro-climatic conditions across India, with major crops including onions, potatoes, tomatoes, cabbages, radishes, and cucumbers. India is the world's largest producer of cauliflower, second-largest producer of onions, and among the top producers of cabbage, peas, potatoes, and tomatoes (Ahmad et al., 2017). The development of high-yielding, disease-resistant varieties and hybrids has boosted vegetable production. However, these varieties often require excessive fertilizer, leading to pest problems. Farmers then turn to chemical pesticides, resulting in pest resurgence, harm to natural enemies, and destruction of beneficial insects (Bhardwaj et al., 2021). Integrated Pest Management (IPM) is a comprehensive approach to pest control that combines biological, cultural, physical, and chemical methods to manage pest populations while minimizing environmental harm. IPM is crucial for sustainable agriculture, reducing dependence on chemical pesticides and their negative effects on human health and the environment (Ram et al., 2012). However, the adoption of IPM practices among vegetable growers in India is inconsistent, influenced by socio-economic, technical, and informational barriers. Factors such as awareness, knowledge, access to resources, and extension services play a significant role in the adoption of IPM (Singh et al., 2022).

In Mau District, Uttar Pradesh, vegetable cultivation is integral to the local economy. This study evaluates IPM adoption levels among vegetable growers in Mau District, aiming to assess the extent of IPM integration and identify the factors influencing adoption. The findings will help governmental and private agencies tailor support and training programs to improve IPM adoption, promoting sustainable farming practices.

METHODOLOGY

The study was conducted in Mau District, Uttar Pradesh, during 2022–2023 to evaluate the adoption of Integrated Pest Management (IPM) practices among vegetable growers. Among the nine blocks in the district, Ratanpura and Kopaganj were purposively selected due to their significance in vegetable cultivation

and representation of diverse agro-economic conditions. These blocks are recognized for their intensive vegetable farming practices and offer a diverse range of socio-economic and agro-ecological characteristics, making them ideal for capturing regional trends in IPM adoption. The purposive selection ensured that the study focused on areas most relevant to its objectives while providing insights applicable to similar regions. A multi-stage sampling procedure was employed to ensure systematic data collection. In the first stage, six villages were randomly selected from each block, totalling 12 villages. In the second stage, farmers in these villages were stratified into four categories based on their landholding size: marginal, small, medium, and large. Proportionate random sampling was then applied to select 120 respondents, ensuring balanced representation of all farmer categories and allowing the findings to reflect the diversity of the farming community.

The sample size was determined using a statistical formula that incorporated the total population of vegetable growers, an estimated proportion of medium IPM adopters, a 5% margin of error, and a 95 per cent confidence level. This rigorous sampling framework ensured that the study was both representative and robust. Data collection involved both primary and secondary sources. Primary data were gathered using a semi-structured interview schedule designed to capture the socio-economic and psychological attributes of respondents, as well as their adoption levels of IPM practices. Secondary data were obtained from agricultural records and reports relevant to the study area. Adoption levels were assessed through a scoring system based on the extent of IPM practices implemented by the respondents, with scores reflecting full, partial, or no adoption. The collected data were analyzed using descriptive statistics and correlation analyses to identify trends and factors influencing IPM adoption. The purposive selection of blocks, combined with a robust sampling framework and rigorous data analysis, ensured that the study findings are reliable, representative, and provide valuable insights for promoting sustainable vegetable farming practices in Mau District and similar agro-ecological regions.

RESULTS

From the Table 1, farmers show a strong preference for practical cultural methods like deep ploughing and mixed cropping, reflecting their effectiveness. Moderate adoption of residue removal and spacing highlights their routine use, while low adoption of crop rotation points to barriers like land constraints. Overall, cultural practices are well-adopted, with scope for improvement in less-preferred methods.

Table 1. Adoption of Cultural Methods in vegetable growing

Statement	Adoption rates		
	High (%)	Medium (%)	Low (%)
Deep summer ploughing	43.34	46.66	10.00
Removal of previous crop residues	25.00	63.34	11.66
Recommended seed rate	13.34	76.66	10.00
Adoption of proper spacing	14.16	74.16	11.68
Adoption of crop rotation	05.84	73.34	20.82
Adoption of mixed cropping	42.50	44.16	13.34
Average Percentage	24.04	63.04	12.92

Table 2. Adoption of Mechanical Methods in vegetable growing

Statement	Adoption rates		
	High (%)	Medium (%)	Low (%)
Roughing practices in crop	18.34	35.00	46.66
Hand picking of insect-pest and their destruction	20.00	23.34	56.66
Use of light and pheromone trap	10.84	25.84	63.32
Monitoring of insect- pest	09.16	24.16	66.68
The burning of pervious crop residues for ratoon crop	33.34	20.00	46.66
Average Percentage	18.44	25.66	55.90

From the above Table 2, mechanical methods show low adoption overall, with labor-intensive practices like hand-picking and pest monitoring facing challenges. Advanced techniques such as pheromone traps are underutilized due to technical barriers, while residue burning sees better adoption due to its practicality. Training and resources are needed to improve adoption.

Table 3. Adoption of Biological Methods in vegetable growing

Statement	Adoption rates		
	High (%)	Medium (%)	Low (%)
Use of bio-pesticides	10.00	53.34	36.66
Use of bio-agent	09.16	14.16	76.68
Use of natural enemies	09.16	17.50	73.34
Use resistant varieties	12.50	61.66	25.84
Use neem-based product	20.00	33.34	46.66
Use bio-fertilizer	31.68	46.66	21.66
Average Percentage	15.51	37.77	46.72

From the above Table 3 the adoption of biological methods in vegetable growing is generally low, with a high proportion of farmers in the low-adoption category. Practices like bio-agents and natural enemies face significant challenges due to limited availability and perceived inefficacy. Bio-fertilizers and resistant varieties show relatively better adoption, driven by subsidies and proven benefits. Overall, biological methods require greater awareness, availability, and demonstration to enhance their adoption.

Table 4. Adoption of Chemical Methods in vegetable growing

Statement	Adoption rates		
	High (%)	Medium (%)	Low (%)
Apply seed treatment practices	10.84	28.34	60.82
Use balance dose of fertilizers	28.34	46.66	25.00
Apply recommended dose of pesticides	18.34	30.84	50.84
Soil treatment	26.66	37.50	35.84
Average Percentage	21.04	35.84	43.12

From the above Table 4, the adoption of chemical methods in vegetable growing is moderate, with a considerable proportion of farmers in the low-adoption category. Practices like soil treatment and balanced fertilizer use show relatively higher adoption,

reflecting their effectiveness and familiarity. However, seed treatment and recommended pesticide doses exhibit low adoption, indicating limited awareness and reliance on post-emergence solutions. Enhanced training and guidance are needed to optimize chemical use sustainably.

Table 5. Correlation coefficient (r) between different Independent variables and Adoption

Variables	Correlation Coefficient value
Age	0.05751*
Education	0.05154*
Caste	0.05666*
Family type	0.06075*
Family size	0.04134 ^{NS}
Occupation	0.07525*
Land Holding	0.06181*
Marital Status	0.10270 ^{NS}
Annual Income	0.04213*
Social Participation	-0.00417*
Risk Orientation	0.21012*
Scientific Orientation	-0.01107*
Extension Contact	0.16976*

*Significant at 0.05%, NS= non-significant

Table 5 the correlation analysis shows positive influences of factors like risk orientation (0.21012) and extension contact (0.16976) on IPM adoption, highlighting the importance of risk-taking ability and regular advisory support. Education, landholding size, and annual income also positively impact adoption, reflecting the role of knowledge and resources. Negative correlations with social participation (-0.00417) and scientific orientation (-0.01107) indicate gaps in community focus and practical application. Family size and marital status showed minimal impact. These results emphasize the need for focused extension services and community-driven strategies to promote IPM adoption.

DISCUSSION

The study found moderate-to-high adoption of cultural methods among vegetable farmers in Mau District. Deep summer ploughing had a high adoption rate (43.34%) and medium (46.66%) due to its effectiveness in pest control and improving soil. Removal of crop residues was moderately adopted by 63.34 per cent, highlighting its role in pest prevention. However, crop rotation had a low adoption rate (5.84% high), likely due to small landholdings and monocropping practices (Tripathi et al., 2012), which mirror findings from similar studies in Haryana, where tomato growers faced constraints in adopting crop diversification strategies due to limited land availability and market-driven monoculture preferences (Anamika et al., 2023) (Anamika et al., 2023).

Mechanical methods, such as roughing (18.34% high) and hand-picking insects (20% high), had lower adoption rates compared to cultural methods. Most farmers (55.90%) reported low adoption, likely due to the labour-intensive nature of these practices, especially given smallholder farmers' labour shortages and time constraints. Additionally, methods like light and pheromone traps (63.32% low) and pest monitoring (66.68% low) were underused due to the technical knowledge and consistent monitoring they require. Limited

extension support or training likely contributed to this. Providing hands-on training and integrating mechanical methods into routine practices could boost adoption. These challenges align with findings from Bundelkhand, Uttar Pradesh, where mechanical IPM adoption was hindered by similar labour shortages and insufficient extension support (Gupta et al., 2020).

The adoption of biological methods was low, with bio-pesticides at 10 per cent high adoption and bio-agents/natural enemies at 9.16 per cent, suggesting gaps in knowledge or availability. Farmers may perceive biological controls as less effective than chemical alternatives due to slower action and variable performance (Singh et al., 2014). Overall low adoption (46.72% low) points to the need for targeted education and incentives. Demonstration plots and success stories could build confidence and encourage wider adoption (Gautam et al., 2017). However, bio-fertilizers showed moderate adoption (46.66% medium), likely due to government incentives, as seen in Manipur, where subsidies increased adoption among cabbage and cauliflower growers (Ram et al., 2012).

Chemical methods showed moderate adoption, with soil treatments having the highest high-adoption rate (26.66%), indicating farmers' reliance on immediate, visible pest management effects. However, seed treatment had a high low-adoption rate (60.82%), possibly due to lack of awareness or preference for post-emergence treatments. Over-reliance on chemicals may stem from their perceived cost-effectiveness and accessibility (Kamal et al., 2018). This trend challenges IPM implementation, as excessive chemical use can cause environmental harm and pest resistance. The over-reliance on chemicals, a concern in many regions including Madhya Pradesh, highlights the need for integrated methods to mitigate environmental harm and pest resistance (Agarwal et al., 2014). The overall adoption levels indicated that most farmers fell into the medium adoption category (49.16%), with only 20.84 per cent achieving high adoption. This distribution suggested that while the basic principles of IPM were understood, full implementation remained constrained by socio-economic factors and limited access to resources (Chouhan et al., 2013). The predominance of medium adoption might have resulted from fragmented extension services and inconsistent policy support. Addressing these challenges through comprehensive training, improved access to inputs, and financial support could elevate more farmers to the high-adoption category (Singh et al., 2018).

The correlation analysis highlights key factors influencing IPM adoption among vegetable growers. Risk orientation (0.21012) and extension contact (0.16976) showed the strongest positive relationships, indicating that risk-tolerant farmers with regular advisory support are more likely to adopt IPM. Other factors, like education, landholding size, and annual income, also positively influence adoption by enhancing farmers' understanding and capacity to implement sustainable practices. Conversely, negative correlations were observed for social participation (-0.00417) and scientific orientation (-0.01107). The negative value for social participation suggests that increased involvement in social organizations does not necessarily enhance IPM adoption and may even act as a barrier. This could be due to the focus of these groups

on non-agricultural issues or resistance to innovative methods within community dynamics. Similarly, the negative correlation with scientific orientation highlights a disconnect between theoretical knowledge and practical application, with some scientifically inclined farmers perceiving IPM as less effective compared to chemical alternatives. Family size and marital status showed minimal impact on IPM adoption. These findings highlight the need for targeted interventions focusing on factors like risk orientation and extension contact. Strengthening training programs, community demonstrations, and extension services can improve IPM adoption, aligning farmers with sustainable practices.

CONCLUSION

The study highlights moderate adoption levels of IPM practices among vegetable growers in Mau District, Uttar Pradesh, with cultural methods being the most adopted and biological methods the least. Key barriers include limited knowledge, labour intensity, and resource constraints. Correlation analysis revealed that education, landholding size, extension contact, and risk orientation positively influenced adoption, while social participation and scientific orientation negatively correlated, indicating gaps in community-driven learning and knowledge dissemination. To improve IPM adoption, targeted extension services, hands-on training, and financial incentives are essential. Demonstration plots and success stories can build farmer confidence in biological methods. Integrated support from governmental and private agencies, along with policy frameworks, can enhance resource accessibility and promote sustainable vegetable farming practices, ultimately improving productivity, environmental health, and farmers' livelihoods.

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Constraints Faced by Rural Youth for Opting Entrepreneurship as Career: A Case Study of Haryana

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HIGHLIGHTS

- Persona like gender discrimination and social like underestimation of the ability of concerned youth constraints play a vital role behind the entrepreneurial mind-set.
- A strong connection between the gender and limited mobility was shown by the Linear-by-Linear connection test (10.784, $p = .001$).

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ABSTRACT

The study was carried out to examine the constraints faced by rural youth for starting their own ventures during 2023. Multi-stage sampling was used for data collection. The data were collected from 396 respondents from three districts of Haryana through a well-structured questionnaire. The relationship of gender was checked with the eight statements of social factors. The data were analysed using Weighted Average Mean (WAM) and constraint faced by rural youth were ranked accordingly. The constraints were categorised in five categories i.e. personal, social, market, financial and government support and subsidy. The major constraints faced by the rural youth were caste biasness, underestimation of individual ability by society, delayed payment of bills, inadequate savings, non-availability of skilled/trained manpower and complexity in availing schemes/subsidies from the government agencies. The relation of gender was found significant with two statements, i.e. lack of family support and limited mobility.

INTRODUCTION

Entrepreneurship is the skill of establishing and managing a business in a way that ensures profitability and long-term sustainability. Entrepreneurs, more than innovativeness, play an essential role in the growth of developing nations. It is regarded as a potent way to boost productivity, competition, market efficiency as well as generating employment, poverty eradication, wealth and regional creation in a country. Businesses significantly contribute by generating employment opportunities and shaping new work environments. Additionally, they are often viewed as a key factor

in enhancing the socio-economic progress of a nation's economy (Meenam et al., 2023; Nain et al., 2013).

India's economy has been greatly impacted by the new businesses, which has a lot of different sector entrepreneurs from rural areas. New venture creation is not only an essential part of economic development, but it also plays a significant role in improving the socioeconomic standing and income of rural youngsters by creating jobs for them (Yadav & Kashyap, 2017). Many R&D organisations have recommended the improved management strategies; however, youth encounter a number of obstacles when implementing these recommendations (Meena et al.,

2015). It is possible to infer constraints from this to describe the issues and challenges which the youth is encountering while starting their own ventures (Maske et al., 2020). Attracting and retaining youth in agriculture (ARYA) program highlights entrepreneurship opportunities across various agribusinesses, showing that locally viable enterprises and entrepreneurial skills are crucial to sustaining and engaging rural youth in agriculture (Gowda et al., 2023).

Nearly all recent graduates search for white-collar work, ideally in the public sector. The number of job openings in the public sector is declining more quickly than the number of graduates leaving schools. An estimate ICAR, (2012) states that 23 per cent of postgraduates (M.Sc.) and 43 per cent of graduates have trouble finding meaningful employment where promotion of entrepreneurship might show up as a workable and realistic answer to this issue.

Considering the aforementioned concepts, it is evident that entrepreneurship can positively affect the labour market by creating much-needed jobs and business prospects. The rural sector has immense untapped potential and presents great business prospects for young entrepreneurs. Active assistance from government policies and programmes makes rural entrepreneurship far more profitable. Thus, the previously mentioned sector may offer a way to address the problem of unemployment. But in order for young people to perceive entrepreneurship as a viable path to self-employment, it is imperative that their perceptions of it be changed. Furthermore, the employment situation over the last few years suggests that a comparatively small proportion of young people are choose entrepreneurship as a career route. The goal of the present study is to explore the different constraints faced by young people of rural areas while starting their own venture. Similar study was conducted by Singh et al., (2021) which shows the entrepreneurial behaviour of skilled youth.

METHODOLOGY

The study was carried out in Haryana in the last quarter of 2023. Multi-stage sampling was used for the purpose of data collection. Three districts of Haryana namely Mahendragarh, Mewat and Fatehabad district were chosen based on highest proportion of rural youth as per the population census, 2011 (Directorate of Census Operations Haryana, 2011). From each of the selected district, three blocks were chosen with the highest proportion of rural youth and from each of the selected block, four villages were chosen with the highest rural population. Further, from each of the selected block, 11 respondents in between the age of 15-29 were chosen randomly resulting in a total sample size of 396 respondents. Descriptive research design was used for conducting the study. The study was carried out to explore the constraints faced by rural youth in opting entrepreneurship as a career option. In this study, the respondents communicated certain limitations that were classified into five distinct categories, viz., personal constraints, social constraints, market constraints, financial constraints, and constraints related to government support & subsidies.

Primary data were collected by using a pre-tested structured questionnaire. The responses on the constraints faced by the rural youth for starting their own business were collected on likert scale with five continuums viz, SA (Strongly agree), A (Agree), N

(Neutral), DA (Disagree) and SDA (Strongly disagree). The scale was developed by Karnsomdee & Phongkaew (2023); Glod (2015); Bagheri & Harrison (2020). Following the proper documentation of their assessments, the statements were evaluated for analysis by computing their weighted mean scores (WMS) (Lal, 2023).

$$\text{Weighted Average Mean} = \frac{\text{Actual scores obtained for the statement}}{\text{Maximum possible score obtained for the statement}}$$

For each statement, the weighted average mean score was calculated, and ranks were given accordingly. The collected data was analysed with help of suitable statistical tests on the basis of mean weighted scores and ranking. Chi-square test was used to check the relationship between gender of respondents and lack of family support, limited mobility.

RESULTS

The constraints for starting new ventures were measured in terms of personal, social, market, financial and constraints related to government support and subsidy. Ranks were given to each of the statement through Weighted Average Mean and discussed below in detail.

Table 1 showed two categories of constraints i.e., personal constraints and social constraints faced by rural youth for opting entrepreneurship as a career option. In personal constraints, the major constraint faced by rural youth was gender discrimination which ranked first followed by the problem of caste biasness ranked as second, lack of awareness about different avenues ranked third and lack of basic business skills, which is considered important for the success of the enterprise ranked fourth. Similar findings were also reported by Sharma et al., (2021) & Kumar et al., (2017). In social constraints, the major constraint faced by the rural youth was underestimation of the ability of concerned youth which ranked on first position. Difficulty in balancing the responsibilities between family and business was ranked second followed by health issues of family members on third rank.

Table 2 depicts three categories of constraints viz., market constraints, financial constraints and constraints related to government support & subsidies faced by rural youth for opting entrepreneurship as a career option. In market constraints, non-availability of skilled/trained manpower was the main constraint as it ranked first. Lack of knowledge about target market, costly labour and lack of knowledge about target population ranked second, third and fourth, respectively. Similar results were obtained in the study of Prasad & Naveena (2021). From financial constraints, it was clear from the data that maximum respondents were facing the problem of delayed payment of the bills followed by inadequate saving both ranked first and second. However, high interest rate of banks and lack of requisite machinery due to financial problem were ranked third and fourth. However, the constraints presented in the table were also reported by Sharma et al., (2021); Surliya & Meena (2024); Shivacharan et al., (2017). From the constraints related to government support and subsidies, the main constraint faced by respondents was difficulties in availing schemes/subsidies from the government agencies. The prevalence of malpractices in the offices and delay tactics followed by concerned officials; non-existence of institutions arranging workshops, hand-on training programs and

Table 1. Personal and social constraints faced by rural youth

S.No.	Statement	SA	A	N	D	SD	WAM	Rank
Personal Constraints								
1	Lack of basic business skills	01	203	161	31	00	3.44	IV
2	Lack of awareness about the different business avenues	03	192	178	23	00	3.44	III
3	Lack of self-confidence	05	139	213	39	00	3.24	VI
4	Low level of operational proficiency with regard to plans and strategies for future growth	08	129	202	57	00	3.22	VII
5	Lack of adequate education and guidance to start a business	19	128	170	79	00	3.22	VIII
6	Gender discrimination	217	77	56	46	00	4.17	I
7	Caste biasness	198	79	65	54	00	4.06	II
8	Low risk bearing ability	37	87	237	35	00	3.32	V
9	Low convincing power	15	81	262	38	00	3.18	IX
Social Constraints								
1	Lack of acceptance by society (Friends/Peer/Family/Group)	08	87	266	35	00	3.17	VIII
2	Lack of family support	07	129	224	35	01	3.27	VI
3	Underestimation of my ability by society	17	203	155	21	00	3.55	I
4	Health issue of family members	23	166	155	52	00	3.40	III
5	Cultural and social taboos	29	137	184	46	00	3.38	IV
6	Difficulty in balancing the responsibilities between family and business	25	154	182	35	00	3.43	II
7	Limited mobility	16	146	195	37	02	3.35	V
8	Lack of entrepreneurial environment	07	116	249	24	00	3.27	VII

(SA=5, A=4, N=3, D=2, SD=1, WAM=Weighted Average Mean)

Table 2. Market, financial and government support related constraints faced by rural youth

S.No.	Statement	SA	A	N	D	SD	WAM	Rank
Market Constraints								
1	High competition in the market	02	126	256	12	00	3.30	V
2	Lack of knowledge about target market	02	155	228	11	00	3.37	II
3	Lack of knowledge about target population	04	144	224	24	00	3.32	IV
4	Costly labour	05	142	235	14	00	3.35	III
5	Non-availability of skilled/trained manpower	06	203	159	28	00	3.47	I
6	Irregular supply of raw material	08	136	185	67	00	3.21	VI
7	Lack of raw material	06	110	182	98	00	3.06	IX
8	High service charge for water & electricity	05	125	180	86	00	3.12	VII
9	Inappropriate distribution channel for finished goods	07	99	225	65	00	3.12	VIII
Financial Constraints								
1	Poor economic status	07	107	236	46	00	3.19	VIII
2	High interest rate of banks	04	135	233	24	00	3.30	III
3	Delayed payment of bills	09	180	181	26	00	3.43	I
4	Lack of requisite machinery due to financial problem	11	155	159	71	00	3.27	IV
5	Costly raw material	09	144	178	65	00	3.24	VII
6	Inadequate assets for collateral security	11	148	172	65	00	3.27	V
7	Inadequate savings	14	141	194	47	00	3.31	II
8	Inadequate capital to start a business	12	120	223	41	00	3.26	VI
Constraints related to Govt. support & Subsidies								
1	Inadequate support from government	00	77	271	48	00	3.07	VI
2	Lack of awareness about government schemes/subsidies	02	104	261	29	00	3.20	IV
3	Complexity in availing schemes/subsidies from the government agencies	04	227	138	27	00	3.53	I
4	Cumbersome and time-consuming process for applying loans from financial institutions/government agencies	07	113	189	87	00	3.10	V
5	Non-existence of institutions arranging workshops, hand-on training programmes and campaigns to improve the entrepreneurial skills locally	06	122	214	54	00	3.20	III
6	The prevalence of malpractices in the offices and delay tactics followed by concerned officials	06	185	177	28	00	3.43	II

Table 3. Chi-Square test (Gender and lack of family support)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.694 ^a	4	.013
Likelihood Ratio	12.526	4	.014
Linear-by-Linear Association	1.574	1	.210
N of Valid Cases	396		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .33.

Chi-Square test (Gender and limited mobility)

Pearson Chi-Square	13.738 ^a	4	.008
Likelihood Ratio	15.985	4	.003
Linear-by-Linear Association	10.784	1	.001
N of Valid Cases	396		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is .67.

campaigns to improve the entrepreneurial skills locally were ranked as second and third major constraint by the respondents respectively. Similar findings were also reported earlier by Sharma et al., (2021) & Patel et al., (2015).

Relationship between gender and lack of family support, limited mobility

The relationship of gender with the social factors was assessed using Chi-square test. The relation of gender was found significant with two statements, i.e., lack of family support and limited mobility (Table 3).

The significant findings about the relationship between the variables under examination were revealed by the chi-square test of association (Table 2). At the 0.05 significance level, there was a statistically significant connection between the variables according to the Pearson Chi-Square statistic (12.694, $df = 4$, $p = .013$) and the Likelihood Ratio Chi-Square statistic (12.526, $df = 4$, $p = .014$). This implied that the gender and lack of family support were having statistically significant relationship with one another. Similar findings were observed in the study of Surliya & Meena (2024). The chi-square test findings showed a substantial correlation between the variables under investigation (Table 2). At the 0.05 significance level, statistically significant relationships were revealed by both the Pearson Chi-Square (13.738, $df = 4$, $p = .008$) and the Likelihood Ratio Chi-Square (15.985, $df = 4$, $p = .003$) tests, suggesting a meaningful relationship between the variables. It implied that there was a significant relation between gender and limited mobility. Additionally, a strong linear trend in the connection between the variables was shown by the Linear-by-Linear connection test (10.784, $df = 1$, $p = .001$), indicating a regular pattern in their interaction.

DISCUSSION

Rural youth were facing problems due to different reasons. Due to orthodox thinking by society, youth were still facing problems like gender discrimination, caste bias, etc. Because of this, a large number of youths did not have proper knowledge about different sectors that could support them for independence. Another

constraint faced by the rural youth was that society underestimated the power of concerned youth in handling business activities. As a result of this, the youth found it difficult to balance the responsibilities between family and business, followed by health issues of family members because society, as well as family, was not supporting them to work for their business. The study by Sharma et al., (2021) found that rural youth face key constraints like fear of failure, lack of family support, awareness, education, financial aid, limited management knowledge, and theft risks in livestock enterprises. The study of Gupta et al., (2014); Baliwada et al., (2017) & Kumar et al., (2017) reported comparable findings.

Furthermore, skilled and trained manpower was not available in the study area, and because of this, the hiring charges for available manpower were too costly. Starting a new business requires higher investments in the initial stage, and the youth usually do not have sufficient funds to start their own venture. Hence, they have to depend on financial institutions for loans due to inadequate assets for collateral security, and they might be facing a lot of difficulties in getting financial assistance. In the study of Shivacharan et al., (2017). Labor shortages and price fluctuations were the key challenges faced by seed, rice mill, and vegetable commission entrepreneurs. However, other constraints were a lack of awareness about government schemes /subsidies, a cumbersome and time-consuming process for applying for loans from financial institutions/ government agencies, and inadequate government support. It revealed that respondents were in getting bank loan facilities through different schemes because of the complex processes. Therefore, it is essential to offer frequent training programs to younger people living in rural areas so they may educate themselves on banking procedures. These findings were supported by the study of Sharma et al., (2021) & Patel et al., (2015). The chi-square analysis revealed significant relationships between gender and both lack of family support and limited mobility, highlighting gender's influence on these social constraints. A linear trend further indicated a consistent interaction between gender and restricted mobility. In their study, Surliya & Meena (2024) also observed these types of relationships.

CONCLUSION

Entrepreneurship provides plenty of opportunities for supporting rural livelihood. The present study analysed various limitations i.e. personal, social, market, financial and constraints related to government support and subsidies. Among all the factors, caste biasness, underestimation of ability by society, delayed payment of bills, inadequate saving, non-availability of skilled/trained manpower and complexity in availing schemes/subsidies from the government agencies were found to be most crucial constraints which were responsible behind a short number of new ventures. To overcome these constraints, the government should provide better schemes and credit facilities. The government and policy makers should frame youth friendly policies to minimize these constrictions and encourage value-addition. Further, valuable and practical trainings must be provided to the rural youth to avoid the above said constraints while starting a new venture. Moreover, the relation of gender was found significant with two statements, i.e. lack of family support and limited mobility.

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Constraints Faced by Pineapple Farmers in Adopting Climate Smart Adaptation Strategies in Kerala

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HIGHLIGHTS

- Market price fluctuations and reduced fruit weight due to adverse climate conditions were identified as the most critical constraints.
- Farmers face challenges such as inadequate labor availability, high input costs, and insufficient government support.
- Access to climate-smart technologies and agricultural subsidies needs to be improved to enhance adaptability.

ARTICLE INFO

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ABSTRACT

The demand for pineapples is significant in Kerala, making sustainable cultivation crucial for long-term agricultural development. Ernakulam, Kottayam, and Kollam are among the key pineapple-producing districts in the state. However, pineapple farmers in these regions face numerous challenges in adopting climate-smart adaptation strategies. This study, conducted during May 2024, aimed to identify and prioritize these constraints using data collected from 130 farmers through personal interviews. Garrett's ranking technique was employed to analyse the data. The findings revealed that market price fluctuations, often caused by reduced fruit weight due to adverse climatic conditions, were the most critical barrier. Other significant constraints included inadequate labour availability, insufficient government support, high input costs, limited agricultural subsidies, restricted access to climate-smart technologies, and inadequate credit facilities. This study emphasizes the need for improved marketing infrastructure, enhanced labour availability, stronger government support, and increased access to climate-smart technologies and financial resources. Addressing these barriers is vital to strengthening the adaptive capacity of pineapple farmers in Kerala and ensuring resilience and sustainability in the face of climate change.

INTRODUCTION

Pineapple (*Ananas comosus* L. Merr.), a tropical fruit from the Bromeliaceae family, is highly valued for its economic and nutritional significance, making it one of the most commercially important fruit crops worldwide (Baruwa, 2013). Globally, fresh pineapple accounts for 50 per cent of trade, followed by canned products (30%) and juice concentrate (20%). In Kerala, pineapple cultivation is a critical component of the agricultural economy, contributing 8 per cent to global production and spanning 10,200 hectares, with an annual yield of 85,500 tonnes. Ernakulam district

leads in production, accounting for over 60 per cent of the cultivated area (Joy, 2013). The state is renowned for its high-quality 'Mauritius Pineapple.'

Despite its resilience, pineapple cultivation in Kerala faces increasing challenges due to climate variability. Ideal growing conditions for pineapple include temperatures between 15°C and 32°C with adequate drainage. However, deviations in rainfall and temperature have led to delayed growth stages, increased costs, and reduced crop revenue (Williams et al., 2018). For instance, the severe floods in Kerala caused disease outbreaks that affected 50 per cent of the remaining crops, significantly degrading fruit quality

(Thomas & Dinesh, 2020). The sensitivity of pineapple to climate change is reflected in reduced yields, smaller fruit sizes, and altered taste and colour, which significantly lower farmers' incomes (Iwuchukwu & Udoe, 2014). According to the Food and Agriculture Organization (FAO, 2008), rising temperatures and water stress due to climate change threaten food production, often leading to crop failures. Defined as long-term changes in climate caused by natural variability or human activity (IPCC, 2001), climate change poses severe risks to sustainable development, affecting health, food security, and infrastructure.

Farmers in Kerala encounter significant constraints in implementing climate-smart practices, such as fluctuations in rainfall, rising production costs, and limited access to technology. Despite its adaptability, pineapple cultivation remains vulnerable to climate-induced disruptions. This research aims to identify the perceived constraints faced by pineapple farmers in Kerala in adopting climate-smart adaptation strategies. Addressing these challenges is essential to promote the adoption of sustainable practices and ensure the long-term productivity and resilience of pineapple farming in the region.

METHODOLOGY

The study was conducted in the districts of Ernakulam, Kottayam, and Kollam in Kerala, focusing on pineapple cultivation. Ernakulam and Kottayam were chosen for their significant pineapple cultivation areas, contributing 51.29 per cent and 28.26 per cent of the state's production, respectively, in 2021-22 (GOK, 2023). Kollam was selected due to a sharp decline in cultivation area, from 531 hectares in 2005-06 to 79 hectares in 2019-20, reflecting challenges faced by farmers, especially after the 2018 Kerala floods that impacted production and productivity (GOK, 2022). A total of 130 farmers participated in the study: 50 each from Ernakulam and Kottayam, and 30 from Kollam. The snowball sampling technique was employed, starting with initial respondents who referred additional farmers, ensuring a representative network of pineapple growers in the region. Data collection was conducted through personal interviews using a pre-tested semi-structured interview schedule. Constraints were identified based on expert input and a review of relevant literature. Garrett's ranking technique was used to prioritize the constraints (Garrett & Woodworth, 1969). The scores for each constraint were aggregated and averaged to determine the mean scores. Constraints were then ranked in descending order based on their mean scores to identify the most critical factors. This systematic approach allowed for an in-depth understanding of the constraints faced by pineapple farmers in adopting climate-smart adaptation strategies, providing actionable insights for addressing these challenges.

RESULTS

The data in Table 1 reveal that market price fluctuations, with a mean score of 67.93, were the most critical constraint faced by pineapple farmers. Adverse climatic conditions reduced fruit weight, resulting in inadequate compensation due to a lack of standardized grading systems. Pineapple growers are compelled to sell their produce at low prices during the peak season, largely due to inadequate marketing facilities. Das et al., (2014) & Das et al., (2016)

Table 1. Constraints faced by pineapple farmers in adopting climate smart adaptation

Sl.No	Constraints	Mean score	Rank
1	Market price affected by decreased fruit weight	67.93	I
2	Inadequate labour availability	58.52	II
3	Lack of government support	57.95	III
4	Lack of agricultural subsidies	55.79	IV
5	High cost of agricultural inputs needed for adaptation strategies	52.55	V
6	Lack of climate smart technologies at field level	51.65	VI
7	Inadequate credit facilities	47.54	VII
8	Lack of proper irrigation facilities	43.97	VIII
9	Lack of access to resources	34.42	IX
10	Lack of access to climate information	30.44	X

emphasized the need for improved marketing infrastructure to address these challenges, while Roy & Ghosh (2022) highlighted similar issues among pineapple growers in Tripura. Labour shortages, scoring 58.52, ranked as the second major constraint. Pineapple farming relies heavily on skilled labour for climate-smart practices like mulching and irrigation. The scarcity of labor forces farmers to either scale down operations or forego important adaptive strategies that require continuous and skilled labor. Ghazi et al., (2023) underscored the critical role of labour availability in sustaining productivity, with Kumar et al., (2021) & Shasani et al., (2020) noting similar challenges in other agricultural contexts.

Lack of government support, with a mean score of 57.95, was the third significant barrier. Farmers depend on subsidies, training, and infrastructure support to adopt climate-smart practices. The lack of such institutional support places pineapple farmers at a disadvantage, as they are unable to access the resources and incentives necessary for transitioning to climate-smart agriculture. Sharma et al., (2016) & Marie et al., (2020) highlighted the importance of institutional backing in empowering farmers to transition to adaptive strategies. The lack of agricultural subsidies (Mean score: 55.79) and high input costs (Mean score: 52.55) compounded financial constraints. Nancy et al. (2015) emphasized the burden of adaptation costs, while Chandran & Podikunju (2021) noted the high expense of implementing climate-smart technologies in Kerala's pineapple sector.

The unavailability of climate-smart technologies (Mean score: 51.65) and limited access to credit (Mean score: 47.54) were additional barriers. This discrepancy may be attributed to a gap between the technological recommendations provided by researchers and the actual adoption of these technologies by pineapple growers. This gap suggests a need for better alignment between research outputs and practical application in the field to enhance both production and productivity (Roy, 2015). Marie et al., (2020) & Talanow et al., (2020) stressed the importance of accessible financing and technology dissemination to bridge the gap between research and field application

Inadequate irrigation facilities (Mean score: 43.97), lack of essential resources (Mean score: 34.42), and limited access to climate information (Mean score: 30.44) further constrained

adaptation. The absence of proper irrigation infrastructure limits farmers' ability to manage water resources efficiently, leading to reduced productivity and making it difficult for them to adapt to erratic weather patterns. Chandran & Podikunju (2021) highlighted water management issues in Kollam, while Talanow et al., (2020) underscored the role of timely climate information in improving decision-making.

DISCUSSION

The most critical constraint identified was market price fluctuations (Mean score: 67.93). Reduced fruit weight due to adverse climatic conditions and the absence of a grading system force farmers to accept prices determined by intermediaries based on visual inspections. This issue underscores the need for standardized grading and marketing infrastructure reforms, aligning with findings by Das et al., (2016). Without addressing price volatility, farmers remain unable to invest in adaptive practices. Labor shortages, scoring 58.52, ranked as the second major constraint. A shrinking agricultural workforce limits the adoption of labor-intensive climate-smart strategies like mulching and efficient irrigation. As noted by Ghazi et al., (2023), attracting a skilled, younger workforce is essential for sustainability. Farmers rely heavily on subsidies and training programs for adopting new techniques. The lack of government support (Mean score: 57.95) and agricultural subsidies (Mean score: 55.79), as highlighted by Sharma et al., (2016), hampers their ability to transition to sustainable practices. High input costs (Mean score: 52.55) and limited access to climate-smart technologies (Mean score: 51.65) further constrained adaptation efforts. Farmers often struggle to afford improved crop varieties and technologies, echoing findings by Nancy et al., (2015) & Baliwada et al., (2017) on the financial burden of adaptation.

Inadequate credit facilities (Mean score: 47.54) and poor irrigation infrastructure (Mean score: 43.97) compounded these challenges, restricting investments in long-term strategies. Limited access to essential resources (Mean score: 34.42) and climate information (Mean score: 30.44) hindered informed decision-making, adding to farmers' vulnerability. These interconnected constraints highlight the urgent need for reforms in market systems, labor policies, government support, and resource access to enhance the resilience of pineapple farmers against climate change.

CONCLUSION

The present study identified several constraints impeding the adoption of climate-smart strategies in pineapple farming. Addressing these challenges requires a combination of policy-level and farm-level initiatives. Efforts should focus on improving marketing infrastructure and introducing standardized grading systems to stabilize market prices. Capacity-building measures, such as training programs and awareness campaigns, are essential to attract skilled labor and enhance farm-level practices. Additionally, strengthening government support through subsidies, expanding access to credit, and promoting climate-smart technologies will empower farmers. Enhancing irrigation facilities and establishing reliable climate information systems are crucial for adaptation. A

coordinated approach involving farmers and policymakers is vital to foster resilience and sustainability in the pineapple farming sector.

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Usage Pattern of Information and Communication Technology Tools among University Faculty Members

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HIGHLIGHTS

- Average usage of ICT tools for personal development, teaching, research and extension found as 86.4, 92.0, 88.9 and 62.7 per cent, respectively.
- Usage pattern of ICT tools in teaching, research, personal development found higher as comparison to extension.

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ABSTRACT

ICT boosts teaching by enabling interactive learning, supports research through advanced data analysis and collaboration tools, and enhances extension services with real-time information and communication. This integration ultimately drives innovation and improves agricultural practices and outreach. Keeping this in view, the study was carried out at the CCS Haryana Agricultural University, Hisar in 2021-22 to assess the usage pattern of ICT tools among faculty members of university. Data were collected with the help of well-structured questionnaire, especially developed for the present study. Four colleges i.e., College of Agriculture, College of Agricultural Engineering and Technology, College of Basic Sciences and Humanities, and I.C. College of Home Science were selected purposively for collection of data. Further, 25 faculty members were selected randomly from each selected college. Eleven independent variables included in the study. Data were analysed with the help of Statistical Package for the Social Sciences (SPSS). The study concluded that usage pattern of ICT tools found less for extension activities as compare to personal, teaching and research among faculty members.

INTRODUCTION

Information and Communication Technology (ICT) can be defined as a basket of technologies which assist or support in storage, processing of data/information or dissemination/communication of data. ICT is an important tool for educational development because it employed in the collection, storage, retrieve, use, transmission and dissemination of information as accurately and efficiently as possible for the purpose of knowledge enrichment, developing decision making and problem-solving ability which helps to increase the communications between students and teachers. It is found that use of e-learning for educational purposes

provides significant advantages over traditional learning (Omoniyi, 2013 & Seoud et al., 2014). However, ICT also used to secure research data, make research results more visible and increase collaboration and sharing among colleagues. Additionally, ICT provides advanced computation capabilities in research to increase speed, improved data storage and management.

As the world's current population will rises from 7.4 to 9.1 billion by 2050, food production will need to increase over this similar time (FAO 2016). So, access and utilization of ICT may become a major determining factor in the development of a modern and sustainable society (Dobrota et al., 2012; Yu et al., 2017; Torkayesh & Torkayesh, 2021) and ICTs have the capacity to retain

and communicate the agricultural information (Okoedo & Omoregbee, 2012; Nain et al., 2019; Niranjan et al., 2023). So, in this situation (continuously increasing population) ICT can help to speed up the dissemination of agricultural technologies and innovation i.e., weather and insect-pests and disease forecasting from research and development organizations to farmers. It helps in farmers’ learning, problem-solving, and access to viable markets for their crops also. Thus, ICT can play a critical role in research and extension to increase professional capacity building among professionals (World Bank, 2011 & Rohila et al., 2017).

Agriculture sector is providing employment to the 48.9 per cent of the total workforce of the country. This sector has dependency of 58 per cent of the population for their livelihood. While, the share of Haryana state in national GDP is estimated at 3.7 per cent (Anonymous, 2024). ICT is an important medium for accessing and disseminating information via use of telephones, mobiles, internet and other communication devices. It can be concluded that ICT plays a pivotal role in agricultural universities by enhancing teaching, research, and extension services. In teaching, ICT enables interactive learning through multimedia resources and online platforms. For research, it facilitates data collection, analysis, and collaboration across disciplines and locations. It also supports extension services by disseminating knowledge and best practices to farmers via digital platforms, mobile apps, and online courses, bridging the gap between academic research and practical application. Overall, ICT streamlines processes, improves accessibility, and accelerates innovation in agriculture. Keeping in view the importance of ICT in teaching, research and extension, the study was conducted to assess the usage pattern of ICT tools among faculty members of CCS Haryana Agricultural University, Hisar (Haryana) India.

METHODOLOGY

Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar, was established in 1970 through a Presidential Ordinance, which was later formalized by the Haryana and Punjab Agricultural Universities Act, 1970, passed by the Lok Sabha. The university was selected as the site for the present study, which was conducted during the 2021-22 academic year. The study focused on four colleges within CCSHAU: the College of Agriculture, the College of Agricultural Engineering and Technology, the College of Basic Sciences and Humanities, and the I.C. College of Home Science. These colleges were purposively selected for the study, and 25 faculty members were randomly chosen from each of the selected colleges, resulting in a total of 100 faculty members. A well-structured questionnaire was developed to assess the dependent variables. Eleven independent variables were considered in the study, including age, sex, educational qualification, job experience, rural-urban background, parental occupation, job preference, job satisfaction, job commitment, training received on Information and Communication Technologies (ICTs), and information-seeking behaviour. The respondents were informed about the purpose of the study to ensure transparency and gain their confidence. The collected data was systematically tabulated, analysed, and interpreted in line with the study’s objectives, using the SPSS software tool for data analysis.

RESULTS

Usage pattern of ICT tools by faculty members

The usage pattern (Table 1) of ICT tools for personal development reveals that faculty members rely heavily on the internet for various tasks aimed at enhancing their professional growth. All respondents (100%) used the internet to search for general information and to prepare essential reports, including self-assessment reports (SAR), career advancement schemes (CAS), and progress and performance reports. A large majority (96%) also utilize online resources such as books, magazines, journals, and articles to stay informed, while 95 per cent respondents, access the latest information relevant to their specific domains. Communication with colleagues is another area where ICT tools are widely used (93%) by the respondents. Additionally, ICTs play

Table 1. Usage pattern of ICT tools by faculty members

Statements	Yes (%)
Internet to search the general information	100.00
Acquire latest information related to domain	95.00
Communicate with colleagues	93.00
Online books, magazines, journals and articles etc.	96.00
Prepare SAR, CAS, progress and performance reports etc.	100
Apply for other post	69.00
Social media for information and entertainment	78.00
Develop and manage personal contact	82.00
ICTs for social networking	81.00
Online shopping	70.00
Collection of course materials	98.00
Online classes	98.00
Class room presentation	96.00
Assignment to students	97.00
To take photographs of class	71.00
Question paper setting	87.00
Online examination/evaluation	94.00
Preparation and submission of results	96.00
Guiding PG students	90.00
Students training and presentation	93.00
Collect data about latest trend in research field	91.00
Visiting different website for research grants	88.00
Software/ application for statistical analysis	90.00
Prepare projects designs	84.00
Prepare projects reports	83.00
Presentation of results	91.00
Discussion/collaboration of lab/field work with other expert	89.00
Attend meeting/workshop of funding agency	86.00
Write research articles/policy paper etc.	94.00
Submission of articles to journals/magazines	93.00
Text /voice message to farmers	53.00
Video clips/photographs for training/demonstration	72.00
Projector/ interactive board for training/demonstration	69.00
To deliver expert lecture	87.00
Mobile/camera for diagnostic purpose	60.00
Organize online trainings	71.00
To develop mobile application	41.00
To develop expert system	45.00
To develop extension content for farmers	66.00
To collect feedback from farmers	63.00

a significant role in personal networking, as 82 per cent of respondents use them to develop and manage personal contacts, and 81 per cent used ICT tools for social networking. Social media also frequently used (78%) by the respondents for information and entertainment purposes. While, the use of ICTs for more transactional purposes such as online shopping (70%) and applying for other posts (69%). This pattern highlights the central role of ICT tools in staying informed, building networks, and managing career advancement.

The usage pattern of ICT tools for teaching demonstrates a high level of integration and reliance on technology in academic practices. Most of faculty members utilize ICT tools for the collection of course materials and conducting online classes. While, majority of respondents i.e., 97 per cent incorporate technology for assigning tasks to students, followed by class room presentations, and preparation and submission of results as 96 per cent. The use of ICT for online examinations and evaluations is also common, with 94 per cent of faculty members adopting these tools to assess student performance. Ninety-three per cent respondents utilize ICT tools for student training and presentations, followed by guide postgraduate students (90%), question paper setting (87%) and take photographs of the class (71%). Overall, the findings highlighted the significant role of ICT tools in modernizing teaching practices, improving student engagement, and streamlining administrative tasks in education.

The usage pattern of ICT tools for research describes a strong reliance on technology for a variety of essential research activities. The use of ICT extends to academic writing and publishing, with 94 per cent of respondents writing research articles and policy papers using digital tools, followed by submitting their articles to journals or magazines online as 93 per cent. Majority of faculty members (91%) use ICT tools to collect data on the latest trends in their research and use technology to present research results, showcasing the role of digital platforms in disseminating findings to a wider audience. The use of software and applications for statistical analysis is also widespread, majority of faculty members (90%) used these tools to process and analyses of research data. Collaboration is another key area where ICT tools are heavily employed, as 89 per cent of respondents engage in discussions or collaborate on lab or fieldwork with other experts through digital means. Only 88 per cent of respondents visit websites to seek research grants, followed by attend meeting/workshop of funding agency, prepare projects designs and project reports as 86, 84 and 83 per cent, respectively. These findings illustrate the crucial role that ICT tools play in enhancing research efficiency, facilitating collaboration, and improving access to resources and publication platforms.

The usage pattern of ICT tools for extension activities reveals that significant portion of respondents (87%) used to deliver expert lecture, followed by utilize video clips and photographs for training and demonstration purposes (72%) and organize online trainings (71%), highlighting the visual and interactive elements that enhance learning and communication. The use of projectors and interactive boards for training purposes is also common, with 69 per cent of respondents employing these tools to facilitate more engaging and effective extension activities. About two-third respondents used

ICTs to develop extension content for farmers, collect feedback from farmers using digital tools and mobile/camera for diagnostic purpose. While, about fifty per cent respondents use ICTs for text or voice messages to share information, followed by develop expert system and mobile application. Overall, while ICT adoption in extension activities is considerable, there is clear potential for expanding the use of advanced technologies to improve service delivery and outreach to rural communities.

Correlation and regression analysis of respondents' personal profile with usage pattern of ICTs

Table 2 explains that job commitment had positive and significant correlation with usage pattern of ICTs, whereas, age, sex, education qualification, training, job preference, parental occupation, rural-urban background, job satisfaction, job experience and information seeking behaviour did not show any significant association at 0.05 level of probability. While, in case of partial regression coefficient of faculty members with utilization of ICTs only job commitment was found significant. However, age, sex, education qualification, job experience, rural-urban background, parental occupation, job preference, job satisfaction, training, and information seeking behaviour did not contributed to utilization of ICTs with faculty members. Further, it is concluded that 11 independent variables included in the study jointly contributed 11.00 per cent variation in the utilization of ICTs with faculty members when other factors were kept constant. It means only 11.00 per cent of the variation in the dependent variables was due to these variables and remaining 89.00 per cent variation in the study due to other variables.

DISCUSSION

Utilization pattern of ICTs tools for personal development (Table 1) may be high due to availability of computer/laptop and internet to each faculty members. ICT also offers a wide range of opportunities and resources that enable teachers to enhance their skills, access information, collaborate with peers, and adapt their

Table 2. Correlation and regression analysis of respondents' personal profile with usage pattern of ICT tools

Variable	Correlation Coefficient	Regression Coefficient	't' values
Age	-0.089 ^{NS}	-1.607	-0.813 ^{NS}
Sex	0.007 ^{NS}	1.135	0.690 ^{NS}
Education Qualification	-0.032 ^{NS}	-1.697	-0.858 ^{NS}
Job Experience	-0.057 ^{NS}	0.197	0.307 ^{NS}
Rural-Urban Background	-0.108 ^{NS}	-1.047	-0.857 ^{NS}
Parental Occupation	-0.031 ^{NS}	0.023	0.040 ^{NS}
Job Preference	-0.038 ^{NS}	-0.100	-0.085 ^{NS}
Job satisfaction	0.106 ^{NS}	0.047	0.229 ^{NS}
Job commitment	0.278*	0.411	2.278*
Training	0.033 ^{NS}	0.461	0.306 ^{NS}
Information seeking behaviour	0.152 ^{NS}	0.434	1.176 ^{NS}

Dependent Variable: Usage Pattern; *Significant at 5 per cent level; $R^2 = 0.118$; Constant Value = 55.759, $Y = 55.759 - 1.607(X1) + 1.135(X2) - 1.697(X3) + 0.197(X4) - 1.047(X5) + 0.023(X6) + 0.100(X7) + 0.047(X8) + 0.411(X9) + 0.461(X10) + 0.434(X11)$

teaching practices to meet the evolving needs of students. Study got support from research findings of Chauhan (2010); Gore & Dawne (2016); Panda et al., (2019) & Malik et al., (2021) who reported that ICT tools were used to find up-to-date information, communication with colleagues, social networking and personal development etc.

While, high utilization of ICT tools in teaching may be due to involvement of faculty members in teaching activities. Another possible reason of high utilization may be e-governance system of CCSHAU for faculty members to update attendance and marks on portal. It also offers a wide range of opportunities and resources that enable teachers to enhance their skills, access information, collaborate with peers, and adapt their teaching practices to meet the evolving needs of students. These findings derive the support from the study of Verma et al., (2020), while, other researchers also concluded that COVID-19 increased the need for the use of ICT in socio-educational interventions. Mishra & Sahoo (2023) concluded that ICT empowers teachers to become more effective, innovative, and adaptable educators, enabling them to create engaging learning experiences and meet the diverse needs of students. ICT also helps the teachers to enrich their own knowledge and skills, foster lifelong learning, and contribute to the growth and success of their students. High utilization of ICT tools in research may be involvement of researcher in a number of activities i.e., latest trend in field, designing experiments, virtual visit of funding institutions, project design, analysis, results, report writing and research paper/articles publication etc. Similar findings were also observed by Tayade et al., (2011) & Verma et al., (2020) who reported that ICTs were used for data collection, processing, updating, analysis, printing and presentation. However, Tunji (2011) concluded that ICT frequently used by researchers and had positive impact on research. Utilization of ICT for extension activities were not as popular as utilization for teaching and research. Possible reasons of low utilization are engagement of faculty members in teaching and research. The findings are consonance with the findings of Malik et al., (2017) who reported that ICT tools use for agricultural extension purpose. However, Rohila et al., (2017); Satapathy et al., (2024); Mukherjee & Jha (2024) suggested that ICT can play vital role to provide relevant information with the aim to empower farmers and promoting sustainable agricultural practices. ICT also helps to finalise the decision making at the right time, to discover best solutions and efficient management for farming community. The results (Table 2) are in contrast of Singh et al, 2023 who concluded that age and education were an important factor in influencing the adoption of ICTs. These finding also in contrast of the findings of Malik et al., (2020). However, Pongener & Jha (2024) recommended that strengthening extension-farmer linkages and improving digital literacy may help enhance the efficacy of the information sources.

CONCLUSION

The results highlighted a strong reliance on ICT tools across various domains, emphasizing their critical role in personal development, teaching, research, and extension activities. The results of the study also reflected that the widespread importance of ICTs for knowledge enhancement and professional interaction along with

facilitating research activities and improving access to global information. There is potential opportunity for further integrating ICT tools into extension services to better serve farmers and rural communities. Overall, the findings indicate a widespread embrace of ICT tools, but also highlight areas where adoption could be strengthened for enhanced outcomes in all fields.

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Training Needs of Member Fish Farmers of FFPOs in Purba Medinipur District of West Bengal

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HIGHLIGHTS

- Medium to high training needs was recorded in 78 per cent of respondents. Key priorities were fish disease control and feeding strategies.
- Most farmers practiced mixed fish farming, and preferred trainers were private staff and input dealers with fisheries institutes and government officials also playing roles.
- Despite FFPO training support, broader extension agency involvement is essential to meet fish farmers' evolving training demands and boost fish production.

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ABSTRACT

The study assessed the training needs of fish farmers who are members of FFPO in the Purba Medinipur District of West Bengal in 2023. The study used a descriptive design, collecting primary data from 120 fish farmers across four FFPOs through semi-structured questionnaire and interviews. The study identified the key training needs of the FFPO members. The primary areas requiring attention included fish disease management (identification and control) ($\bar{x} = 3.2$), feeding strategies and feed formulation ($\bar{x} = 3.02$), water quality management ($\bar{x} = 3.0$), fish breeding ($\bar{x} = 2.67$), pond construction or renovation ($\bar{x} = 2.65$), marketing strategies ($\bar{x} = 2.61$), and selection of quality seed, species, and stocking density ($\bar{x} = 2.52$). Overall, most members exhibited medium (52.5%) to high (25.83%) training needs. There is a need for targeted training in these critical areas to improve fish-farming practices. Preferred trainers included private staff, input dealers, and medicine company representatives (77.5%), followed by fisheries institutes (65%) and government officials (40.83%). The study concluded that while FFPOs provide valuable training, there is a need for additional effort from other extension agencies to address the identified training gaps.

INTRODUCTION

Fishery and aquaculture sectors are vital to India's economy, contributing to national income, nutritional security, employment, social objectives, and export earnings (Dhara et al., 2016; Mallick, 2017; Eseroghene & Ikechukwu, 2018). These sectors have evolved from traditional subsistence activities to diversified commercial enterprises with untapped potential (Mahanayak & Panigrahi,

2024). They provide livelihoods for millions of fishermen and fish farmers who are central to India's socioeconomic framework through food production, job creation, and income generation (India CSR, 2023; IBEF, 2022; Rajeev & Bhandarkar, 2022). Recognizing the need to support small-scale fish farmers in achieving sustainable practices and improved socioeconomic conditions, initiatives such as the Pradhan Mantri Matsya Sampada Yojana (PMMSY) have facilitated the formation of Fish Farmer Producer Organizations

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(FFPOs) (Ministry of Fisheries, Animal Husbandry & Dairying, 2023; Rani, 2022). These organizations aim to enhance fish farmers' skills, livelihoods, and long-term sustainability in the fisheries value chain.

Improved understanding of market dynamics, better targeting of interventions, enhanced competitiveness, increased economic opportunities and improved policy making are few strong areas of FPOs (Singh et al., 2023). FPOs are help reducing transactional costs (Parthiban et al., 2015). Fish farmers can boost their income in three main ways: purchasing farming inputs at reasonable prices via collective bargaining, enhancing their skills through targeted training, and securing better prices by reducing reliance on middlemen. Skill enhancement and capacity building are crucial for increasing farmers' income. FFPOs serve as collective platforms that enable farmers to improve profitability by offering various services. These include bulk purchasing of inputs at lower costs while maintaining quality, providing need-based training, linking farmers to governing bodies, and offering financial and advisory support from experts (Kumari et al., 2022; Pati, 2022; Mondal et al., 2023). To maximize the benefits, it is crucial to assess the training needs of FFPO members to identify areas for skill enhancement. This assessment will guide FFPOs and extension agencies in determining where to focus their training efforts, ultimately enabling farmers to increase their profits and improve their livelihoods.

Training equips individuals with the knowledge, skills, and attitudes necessary for improved performance (Meenambigai & Seetharaman, 2003). It bridges the gap between actual and desired performance, enhancing farmers' confidence in managing issues, minimizing risks, improving productivity, and adapting to new technologies (Makwana & Bhatt, 2021; Famuwagun, 2015). Purba Medinipur District in West Bengal is a prominent fish farming hub, supported by abundant water resources and a thriving fishery sector that significantly contributes to local socioeconomic development. Assessing the training needs of small-scale fish farmers is essential; however, existing studies lack a scientific analysis of the training needs of FFPO members. While FFPOs organize need-based training on the technical and marketing aspects of fish farming, there are still critical areas that require attention from FFPO officials, extension agencies, and government bodies. So, the specific objective of the study is to assess the training needs of the member fish farmers of the FFPO.

METHODOLOGY

The study was carried out in the Purba Medinipur District of West Bengal in 2023. Out of fourteen Fish Farmers Producer Organizations (FFPOs) in the district (District Controller, Food & Supply, Purba Medinipur, 2022), four were selected for the study based on specific criteria: operational success of over 3 years, significant membership (over 400 members), and a turnover exceeding Rs. 1 crore in the fiscal year 2021–2022, as verified by audit reports. The chosen FFPOs were Tamralipta Fish Producer Company Limited, Global Moyna Farmers Producer Company Limited, Divinius Farmers Producer Company Limited, and Patashpur-II Farmers Producer Company Limited. Thirty respondents were selected from each FFPO, totalling 120 respondents, using a simple random sampling without replacement

technique. Descriptive research design was employed and primary data were collected through a semi-structured interview schedule. For identification of major thrust area of training need and extent of training need, responses from the respondents were rated on four-point continuum viz., most needed, needed, least needed and not needed by assigning a score of 4, 3, 2 and 1, respectively followed by Hijam et al., (2015). The sum of the mean rating scale was divided by 4 that is, $(4+3+2+1=10/4 = 2.50)$. Any mean score greater than or equal to 2.50 was regarded as the training needs for the fish farmers in the study area. Further the respondents were grouped into three categories based on mean and standard deviation. The relationship between two categorical variables of such independent variables and training need was checked by implementing a non-parametric test of chi-square value estimation to draw a conclusion.

RESULTS

The study identified the areas of training need by the members of FFPO. It was revealed that some broad areas which had the more thrust of training need (depicted in Table 1) were fish disease related (identification and control) ($\bar{x} = 3.2$), feeding strategy and feed formulation ($\bar{x} = 3.02$), water quality management ($\bar{x} = 3.0$), fish Breeding ($\bar{x} = 2.67$), new pond construction or old pond renovation ($\bar{x} = 2.65$), marketing strategy ($\bar{x} = 2.61$), selection of quality seed and species and their stocking density ($\bar{x} = 2.52$). other areas also should be look after like integrated farming ($\bar{x} = 2.3$), harvesting techniques ($\bar{x} = 2.23$), ongoing culture management (liming, fertilizing, fish health monitoring etc.) ($\bar{x} = 2.19$), combination of fish species to be stocked ($\bar{x} = 2.14$), value addition ($\bar{x} = 2.03$), diversified aquaculture and system diversification ($\bar{x} = 2.01$).

With regard to level of training need of the respondents (presented in Table 2), it was found that the majority of respondents (52.5%) reported a medium level of training need followed by 25.83 per cent of respondents indicated a high level of training need and 21.67 per cent of respondents reported a low level of training need.

Table 1. Percentage distribution of respondents on training needs on different aspect of aquaculture (N=120)

S.No.	Broad areas of training need	Mean Score (\bar{x})
1.	New pond construction or old pond renovation	2.65*
2.	Water quality management	3*
3.	Selection of quality seed, species and their stocking density	2.52*
4.	Combination of fish species to be stocked	2.14
5.	Feeding strategy and feed formulation	3.02*
6.	Ongoing culture management (liming, fertilizing, fish health monitoring etc.)	2.19
7.	Integrated farming	2.3
8.	Fish Breeding	2.67*
9.	Diversified aquaculture and system diversification	2.01
10.	Fish disease related (identification and control)	3.2*
11.	Harvesting techniques	2.23
12.	Value addition	2.03
13.	Marketing strategy	2.61*

Source: (Field Survey, 2023)

Mean cut off = 2.5 (*means training need)

Table 2. Distribution of respondents according to their level of training need (N=120)

S.No.	Level of training need	Frequency (Nos.)	Percentage (%)	Rank
1.	Low (<27.54)	26	21.67	3
2.	Medium (27.54 to 37.66)	63	52.5	1
3.	High (>37.66)	31	25.83	2

Mean = 32.6; Standard Deviation = 5.06

Regarding the preferred extension agency for training purpose (Figure 1), it was revealed that the majority of respondents (77.5%) preferred training to be conducted by private staff, input dealers, and representatives of medicine companies. This was followed by 65 per cent who preferred fisheries institutes, and 55.83 per cent who favoured NGOs as their training providers. Additionally, 40.83 per cent of respondents preferred government officials, such as block-level officials (Fishery Extension Officers), Fish Farmers

Development Agency (FFDA) and Brackish water Farmers Development Agency (BFDA), while 26.67 per cent expressed a preference for Krishi Vigyan Kendra.

Based on the constraints faced by members of the FFPOs for achieving better profit (Figure 2), the highest-rated challenges included the lack of storage and processing facilities, with a mean score of 2.7. This is followed closely by the high cost of input materials (2.65) and high disease occurrence with less productivity (2.63). Poaching and poisoning also present a significant challenge with a mean score of 2.59. Difficulty in identifying quality fish seed, feed, and medicine scored 2.49, and lack of knowledge about scientific fish farming and crop failure was rated at 2.43. Other notable constraints included a lack of facilities for soil and water testing, insufficient capital for scientific culture, high price fluctuation, poor transportation facilities, and inability to create value addition and branding of produce. The lowest-rated constraint was the lack of export orientation, with a mean score of 2.27.

Figure 1. Distribution of respondents on preferred extension agency to conduct training through FFPO

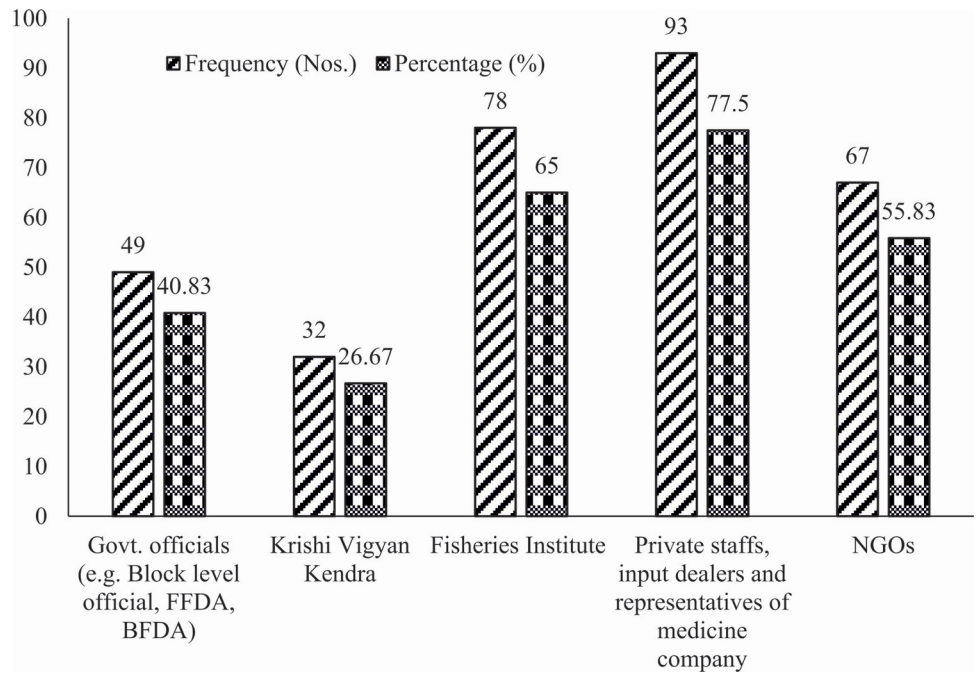
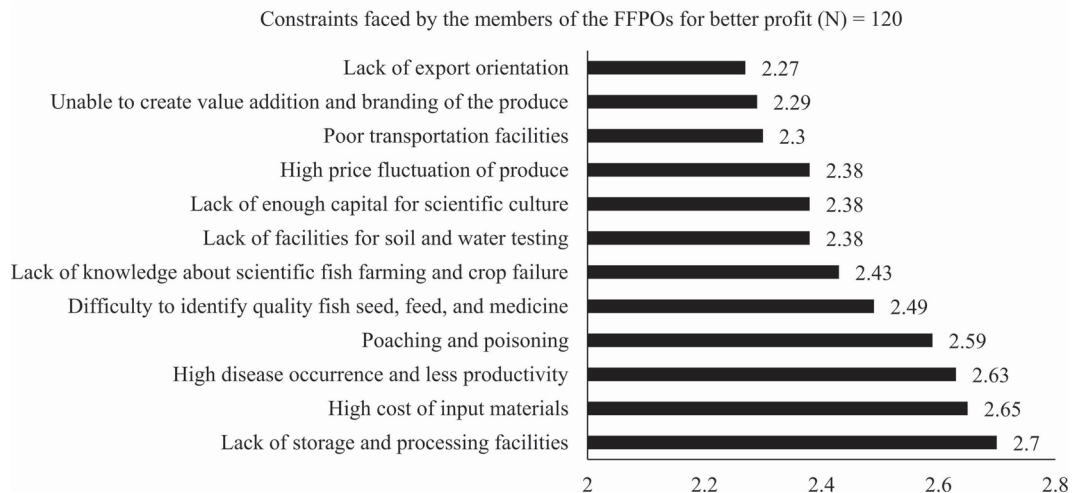


Figure 2. Distribution of respondents based on constraints faced by the members of the FFPOs



Further, the relations of independent variables (demographic profile of the respondents) and dependent variable (training need) is assessed by the estimation of Cramer's V value in Chi-statistics (Lee, 2016) (Table 3). It was found that some variables having very strong (Cramer's V 0.80 – 1.00) relation with training need like farming experience ($\chi^2 = 199.751^*$, Cramer's V = 0.912), occupation ($\chi^2 = 94.765^*$, Cramer's V = 0.889), economic motivation ($\chi^2 = 186.595^*$, Cramer's V = 0.882), annual income ($\chi^2 = 177.089^*$, Cramer's V = 0.859), risk orientation ($\chi^2 = 176.708^*$, Cramer's V = 0.858), number of training attended ($\chi^2 = 165.043^*$, Cramer's V = 0.829), education ($\chi^2 = 160.112^*$, Cramer's V = 0.815), and Scientific orientation ($\chi^2 = 153.968^*$, Cramer's V = 0.801).

Table 3. Association between demographic profile and training need of member fish farmers of FFPO

Variables	Pearson Chi square (χ^2) value
Age (chronological year)	149.005*Cramer's V value = 0.788
Education (class)	160.112*Cramer's V value = 0.817
Farming experience (year)	199.751*Cramer's V value = 0.912
Farming area (Acre)	151.825*Cramer's V value = 0.795
Annual income (Rs.)	177.089*Cramer's V value = 0.859
Occupation	94.765*Cramer's V value = 0.889
Type of culture	134.715*Cramer's V value = 0.749
Economic motivation	186.595*Cramer's V value = 0.882
Risk orientation	176.708*Cramer's V value = 0.858
Scientific orientation	153.968*Cramer's V value = 0.801
No. of Training attended	165.043*Cramer's V value = 0.829

*Significant at 0.01 level of probability (2-tailed)

DISCUSSION

The study presents a comprehensive assessment of the training needs among member fish farmers of FFPOs in the study area, revealing the focus areas and the overall level of training requirements. In terms of priority training areas, the highest training need was observed in fish disease management, with emphasis on disease identification and control (mean score $\bar{x} = 3.2$) (Hijam et al., 2015). This finding highlights a critical area where farmers likely face recurrent challenges impacting fish health and yield. Addressing disease management through structured training sessions could equip farmers with the skills needed to recognize and control diseases, ultimately reducing losses and enhancing productivity. Feeding strategy and feed formulation ($\bar{x} = 3.02$) was another significant area of training need. Proper feeding practices are essential for growth and efficiency, directly affecting farm profitability. Training on cost-effective and nutritionally balanced feed formulation could provide farmers with sustainable options to improve growth rates and feed efficiency. Similarly, water quality management ($\bar{x} = 3.0$), another priority area, plays a fundamental role in aquaculture; thus, imparting knowledge on maintaining parameters like dissolved oxygen, pH, and nutrient levels would enable farmers to sustain optimal rearing conditions. Fish breeding techniques ($\bar{x} = 2.67$) and pond construction or renovation ($\bar{x} = 2.65$) were identified as further areas of training need. Breeding techniques are complex and require understanding reproductive cycles and environmental conditions for successful spawning, whereas knowledge of pond design and construction is crucial for creating an ideal environment for fish

growth. These skills could help farmers increase fish stock quality and productivity. Additionally, marketing strategy training ($\bar{x} = 2.61$) is of significant importance. In an increasingly competitive marketplace, equipping farmers with skills in market analysis and product positioning can help them maximize returns and expand their customer base. Furthermore, knowledge about selecting quality seed, determining suitable stocking densities, and choosing appropriate species ($\bar{x} = 2.52$) ensures a balanced ecosystem within ponds, optimizing growth and yield.

Regarding the overall level of training need among the respondents, the study found that a majority expressed a medium level to high level of training need (Hijam et al., 2015; Makwana & Bhatt, 2021; Makwana et al., 2021). By focusing on the priority areas identified, FFPOs and extension agencies can address critical gaps in fish farming skills and knowledge, thereby supporting members in adopting sustainable practices and enhancing productivity in the region. This distribution shows a clear inclination towards private and specialized fisheries institutions for training among FFPO members (Figure 1). Providing targeted training opportunities for FFPO members could significantly enhance their operational efficiency, resilience, and market participation, fostering the long-term sustainability and profitability of fish farming in the region.

Respondents were encountered lot of constraints, where some of constraints were mostly cut down the profit of respondents like high cost of input materials, it can be addressed though more powerful collective bargaining. High disease occurrence with less productivity can be addressed through proper training. So, here proper infrastructure and value chain with significant backward and forward linkages will be recommended (Mondal et al., 2022). The study explores the relationship between the demographic characteristics of FFPO member fish farmers and their training needs, using Cramer's V analysis to reveal significant associations. Among the variables examined, farming experience showed a very strong relationship with training need ($\chi^2 = 199.751$, Cramer's V = 0.912) (Makwana & Bhatt, 2021). Farmers with extensive experience may require more advanced training, focusing on innovations in aquaculture, whereas less experienced farmers might benefit from foundational skills. Those for whom fish farming is the primary occupation likely demand more intensive training, as they are more dependent on maximizing productivity and profitability. The study findings illustrate the importance of considering demographic factors when designing training programs for FFPO members. Customizing training based on variables such as experience, occupation, economic motivation, and education can enhance engagement and effectiveness, ensuring that training programs meet the diverse needs of FFPO members. So, more concerted effort is needed to fulfil the thrust area where the maximum training will be required of fish farmers regarding their farming aspect.

CONCLUSION

Most respondents demonstrated medium to high levels of need, particularly in areas such as disease management, feeding strategies, water quality, and marketing. While farmers have shown a preference for training conducted by private staff, input dealers, and representatives from medicine companies, there is a critical need

for government and extension agencies to strengthen their support. Government efforts should extend beyond financial assistance to include more proactive engagement by field-level staff. Extension services must prioritize a stronger connection between farmers and line departments. The emphasis should be on building farmers' capacity to adopt new technologies effectively and addressing information gaps that hinder sustainable production. Extension service providers should focus on high-priority areas and enhance access to knowledge through innovative methods like dedicated phone-based support for real-time information exchange with experts and effectiveness of training also be measured. More inclined effort should need through line organizations and FFPO body themselves to bridge the knowledge gap.

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Author's contribution

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

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Exploring the Strategies, Utilisation and Limitations of Digital Tool Adoption in Sugarcane Farming

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HIGHLIGHTS

- The use of digital technology in sugarcane farming may be increased by removing obstacles via better education and early mentoring.
- Social, economic, and technological limitations impede the use of digital in farming operations.
- Mobile technology access and training substantially help sugarcane growers.

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ABSTRACT

The study investigates how sugarcane farmers are currently using digital technologies, identifies the obstacles to their efficient use, and suggests ways to improve the digitalization of sugarcane farming methods. The research was carried out during 2024 in Deoria (district) Sugarcane Committee's Jaura Bazar centre "A", Uttar Pradesh, which is the Deoria Sugarcane Committee's highest-producing sugarcane centre. Purposive sampling was used to choose the sugarcane committee and centre, while random sampling method was used to select the villages and respondent farmers. Garrett's ranking approach was used to assess the constraints of digital tools and technology as perceived by sugarcane cultivators. Data was collected from 230 respondents using a pre-structured interview schedule, revealing that mobile applications are mostly used for seed treatment and pest control in sugarcane farming, and they are less frequently used for other tasks. The primary barriers include technological challenges, budgetary limitations, and societal concerns. It is suggested to use strategies like offline apps, training, free subscriptions, and local language assistance to boost acceptability.

INTRODUCTION

Sugarcane and sugar play a crucial role in the Indian economy, trade, and lifestyle. India is the second-largest producer of sugarcane globally, following Brazil, and is the world's largest consumer of sugar. According to a government estimate, Uttar Pradesh is India's second-largest producer of sugarcane, after Maharashtra. As information and communication technologies (ICT) and precision agriculture instruments are integrated, agricultural management techniques are being enhanced. Through improved input applications, communication across various hardware and datasets, and reduced production costs, this integration intends to improve

the sustainability of the sugarcane crop production system (Molin et al., 2024) The government of India's "Digital India" program intends to provide e-access to government services that are linked to daily living to individuals in urban and rural areas. One method for improving productivity and revenue in agriculture throughout the world is digital agriculture (Beriya, 2020). Digital transformation in agricultural and rural areas is becoming a key priority for global policymakers (Trendov et al., 2019; World Bank, 2017, 2019). Farmers have seen significant advantages from information and communication technologies (ICTs), particularly with the integration of mobile apps and digital technologies into agriculture and related sectors. Agro-advisory service delivery through mobile phones has

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been the subject of several experiments in India over the past few years, including Fisher Friend, M-Krishi, IFFCO Kisan Sanchar Limited (IKSL), Reuters Market Light (RML), Kisan Sanchar, and the most recent initiative, the Digital Agriculture Mission 2021–2025 (Shanthy et al., 2022). The ability of ICT to meet farmers' information and knowledge demands and assist them in making timely decisions that eventually result in a considerable increase in their livelihood has once again been demonstrated by the Paddy Expert System mobile application. (Karthikeyan and Kumar, 2022). Pandey (2017) found that 99 per cent of farmers use some form of media, whether it is traditional or folk media, electronic media, or new media. ICTs are essential for providing farmers with information that helps them make decisions about cropping patterns, selecting high-yielding seeds, applying fertilizers, managing pests, and marketing their products, among other aspects (Meera et al., 2004). Recently, the expansion of ICTs has led to heightened expectations that these technologies will provide quick, reliable, and accurate information in a user-friendly format (Shalendra et al., 2011). ICT has the power to transform farming methods, boost production, and improve farmers' livelihoods in the setting of India's dynamic and diversified agrarian economy (Adu, 2020). The degree of ICT adoption in agriculture is also significantly influenced by technical limitations, such as the accessibility of infrastructure, technical expertise, and support services (Patra et al., 2020). ICT supports farming communities by offering information on input availability, advanced technologies, early warning systems for pests, diseases, and natural disasters, as well as credit, market prices, and competition (Yekini & Hussein, 2008). Digital transformation is widely viewed as the key solution to the challenges faced by agriculture and rural areas (Trendov et al., 2019; World Bank, 2019). With this in mind, the study explores the strategies, utilisation and limitations of digital tool adoption in sugarcane farming.

METHODOLOGY

The Department of Agriculture and Farmers Welfare's Government of India 2023 report states that Uttar Pradesh is India's second-largest producer of sugarcane after Maharashtra. In Uttar Pradesh, Jaura Bazar center "A" was selected purposively as it is the highest sugarcane-producing centre situated in the Deoria Sugarcane Committee (Cooperative Sugarcane Development Committee Limited 2024, Deoria). Random sampling procedure was used to select villages and respondents. Data collection was done through interviewing respondents using a pre-structured interview schedule with 230 respondent farmers. The study collected both primary as well as secondary data. The secondary data were collected through different sources like portals/websites and other exiting records of the National and State Agriculture portal and the Indian Council of Agricultural Research reports on sugarcane farming. The other relevant data was collected from official records, research papers, the internet, journals, news articles, etc. The farmers who are growing sugarcane, as well as both male and female farmers, were included in this study; farm labourers who are working on sugarcane farms were excluded from this study. Jaura Bazar centre 'A' has a total of sixteen villages, out of which eight villages were selected randomly for the study, namely Jaura Khas, Jaura Muglahi,

Noniyapatti, Hanumanganj, Kanaura, Vishunpur Upadhyay, Dohari Patti, and Saraiya Mahant Patti. Twenty-eight respondents were selected from each village randomly, which made a total of 230 respondents. After tabulating the responses, basic statistical methods such as percentages, frequency, and Garrett's ranking method were used to analyze the data, and the results were then analyzed. Considering the above limitations, farmers were requested to prioritize the challenges faced by them. The Garrett Ranking Technique is used to determine the final ranking of restrictions, which are expressed as numerical ratings. Compared to a simple frequency distribution, it offers a benefit since it distributes the constraints based on the respondents' numerical relevance. According to this, limitations with an equal number of responses may be given different rankings. The ranks were converted into percentages using Garrett's method.

RESULTS

The results related to the utilization of digital tools as well as challenges encountered while using digital tools associated with sugarcane farming and strategies for enhancing the digitalization in sugarcane agricultural practices are discussed in this section.

Table 1. Use of mobile applications/digital tools for agricultural assistance in agriculture activities

Activities	Percentage
Land preparation	12.1
Selection and purchase of seeds	35.6
Seed treatment	71.3
Plantation	4.8
Managing irrigation	18.7
Fertilization	5.2
Weeding	8.7
Arrangements for protection against pests & diseases	72.6
Monitoring and maintenance	13.1
Harvesting	0.7
Storage and marketing	3.8
All stages	13.1

Table 1 shows the distribution of respondents (n=230) who use digital tools or mobile applications to help with different agricultural tasks. An emphasis on maintaining crop health and production is shown in the large majority of respondents' reliance on digital technologies for seed treatment (71.3%) and pest and disease prevention (72.6%). The significance of seed selection and purchasing (35.6%) and irrigation management (18.7%) in early and mid-stage farming operations is reflected in their moderate utilization. Activities such as weeding (8.7%), fertilizing (5.2%), and land preparation (12.1%) have comparatively low levels of participation. The steps that are least utilized are harvesting (0.7%) and storage/marketing (3.8%), which indicate that post-harvest procedures have not fully incorporated digital technology. Notably, just 13.1% utilize digital technologies throughout all phases of agriculture, indicating potential for further implementation across the agricultural continuum. This data demonstrates farmers focused yet unequal adoption of digital technology.

Table 2. Constraints faced by sugarcane cultivators in adoption of digital tools (n = 230)

Category	Specific Limitations	Mean Score value	Rank
Social Limitations	Lack of education and training	76.96	II
	Lack of early guidance (understanding and using digital tools)	72.49	III
	Lack of self-confidence	67.89	IV
	Security of personal and agricultural related data	63.63	V
	Language-related problems	35.33	VI
	Concerns about security and fraud	78.45	I
Financial Limitations	Lack of trust in online banking systems	75.07	I
	Complex documentation processes	51.92	VI
	Limited branch network	60.76	V
	Lack of financial literacy or awareness	74.2	II
	Lack of knowledge about the use of online banking	69.89	III
	Insufficient loan amount	29.04	VIII
	High interest rates	38.38	VII
Technical Limitations	Inadequate customer support	68.43	IV
	Lack of access to the Internet	37.81	III
	Smart phone technological inaccessibility	57.83	I
	Limited internet access in rural areas	39.17	II

Table 3. Strategies to enhance the utilization and accessibility of digital devices in the farming community

Strategies	Percentage
Customized services (person or Location) like Mandi, village, etc	20.0
Subscription to digital services should be made available free of cost/Access without internet	80.3
Mobile application available in local language	39.3
Agricultural applications that can run even without internet	39.0
Free training and workshops on using digital tools	71.0
Audio-based digital devices	19.3
Others	01.7

Constraints in the adoption of digital tools in sugarcane cultivation and related work

In terms of social, economical, and technological limits, the table lists the several obstacles that sugarcane farmers have while implementing digital tools. Regarding "social limitations," the biggest obstacle is fears about fraud and security (mean score: 78.45), which comes in first, followed by lack of education and training (76.96) and lack of early guidance (72.49). Further impeding the usage of digital technologies include lack of self-confidence (67.89) and language-related problems (35.33). As the top-ranked concern in this area, the "financial limitations" draw attention to the lack of trust in online banking systems (75.07). Lack of understanding about internet banking (69.89), lack of financial literacy (74.2), and lack of knowledge about online banking (69.89). Farmers' capacity to access and successfully use digital technologies is also impacted by complex documentation procedures (51.92), limited branch networks (60.76), and problems like high interest rates (38.38) and inadequate loan amounts (29.04) are further financial limitations. The most significant issue in the technical constraints category is the absence of a smart phone technological inaccessibility (57.83), which limits farmers' digital involvement. This is followed by

limited internet connection in rural regions (39.17) and no access to the Internet (37.81). For farmers looking to use digital technologies to enhance their farming methods, these obstacles pose serious challenges. In short, farmers' use of digital technology would be greatly increased if these problems were resolved by better instruction, direction, and infrastructural support-such as increased internet connection and device availability.

Table 3 outlines several strategies meant to improve the agricultural community's use and accessibility to digital devices. Offering free digital service subscriptions/Access without internet was the most popular strategy, as indicated by 80.3 per cent of respondents. The proposal for free workshops and training on digital technologies comes next, with 71 per cent of participants supporting it. Additional noteworthy strategies include making sure agricultural applications can operate without internet access (39%), offering mobile applications in local languages (39.3%), and offering person-based services provided to particular areas, such as Mandi villages (20%). Only 19.3 per cent supported audio-based digital gadgets, which received a smaller amount of focus. Less than 6 per cent of participants proposed other strategies, such as monthly campaigns with government assistance. These results collectively show a high need for easily available, free digital materials and instructional assistance to promote increased use of digital technologies in agriculture.

DISCUSSION

The study highlights the increasing but inequitable usage of digital technologies among sugarcane producers while exploring the challenges and strategies needed for greater integration. This trends in farmers usage of digital tools for different agricultural tasks are consistent with research finding of Jadhav (2024) on the use of digital technology in farm families in Hiware Bazar, India. He found that although farmers use digital tools extensively for weather forecasting and crop monitoring, they still participate in few post-harvest activities such as marketing and storage. This implies that although digital technologies are improving productivity in specific

phases of agriculture, their incorporation into the full farming process is still developing. An analysis of the effects of digital revolution on Indian agriculture was also published in the *International Journal of Advanced Multidisciplinary Research*. According to Prakash et al., (2024), farmers who used digital tools to maintain soil health, forecast weather, and monitor crops reported increased productivity and yield. It also pointed out that post-harvest phases like marketing and storage had a comparatively low use of digital solutions. To fully benefit from digital agriculture, these studies highlight the necessity of focused interventions that encourage the use of digital technologies at every stage of the farming process, including post-harvest operations.

The report also identifies significant challenges that sugarcane growers have when integrating digital technologies. Social barriers, including concerns about fraud and data security (mean score: 78.45), reflect the need for building trust in digital platforms, which was also highlighted by Tsai et al., (2021). The underutilization of mobile banking has also been linked to security concerns in other studies, including those by Gomathinayagam et al., (2019) & Singh et al., (2019). These issues are made worse by a lack of awareness and early support, as farmers often lack the skills needed to effectively deploy digital solutions. Adoption can be hampered by financial constraints, as seen by onerous administrative processes (51.92) and a phobia of online banking (mean score: 75.07). Similar to Mahalakshmi et al., (2015), who identified a lack of technical expertise as a key obstacle to ICT adoption, technological limitations are also important. Two examples are limited smart phone availability (57.23%) and poor internet access (39.17%). The study recommends many strategies to address these problems, including free training sessions (71%), free digital service subscriptions (80.3%), and offline-capable apps (39%).

A complete approach to promoting digital adoption is also emphasized in the paper. Important initial steps include early digital guidance programs, targeted interventions to increase confidence, and affordable internet and phone connectivity. Initiatives such as integrating online business facilitation and market data into digital platforms are essential for satisfying the unique needs of agricultural communities. These results are consistent with Lokeswari (2016), who suggested improving ICT infrastructure and training farmers to use market data more effectively. In keeping with Rohit et al., (2023), who noted that awareness-raising campaigns are required to maximize the use of ICT technologies, the research also emphasizes the value of education and training in enhancing digital literacy. Overall, the findings indicate that digital technologies have the potential to significantly increase sugarcane output by fostering better information exchange and decision-making. Targeted programs that offer instruction in digital skills and basic technical knowledge are essential to bridging the digital divide in agriculture. Farmers may boost output and adopt more sustainable farming practices by using all-encompassing solutions that tackle social, economic, and technical challenges.

CONCLUSION

The findings suggest a potential for wider adoption across all phases of agriculture, since digital technologies are extensively used for crop health and early-stage agricultural operations but becoming

less common in post-harvest procedures. The usage of digital instruments is hampered primarily by technological, financial, and social barriers. While social issues like fraud concerns, a lack of education, and early mentorship score highest, financial issues include things like a lack of financial literacy, limited access to low-cost loans, and mistrust of online banking systems. The absence of cell phones and poor internet connectivity remain significant technical obstacles. To overcome these challenges, farmers support initiatives like regional training programs, offline-capable applications, free digital service subscriptions, and mobile apps in local languages. These regulations improve accessibility and utility for farmers while addressing financial and infrastructural concerns. By tackling these issues holistically through education, specialist support, and infrastructure improvements, the adoption of digital technology will accelerate and eventually allow farmers to update their practices and increase agricultural productivity.

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